2ND COPY

U.S. ARMY
MATERIEL COMMAND

— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

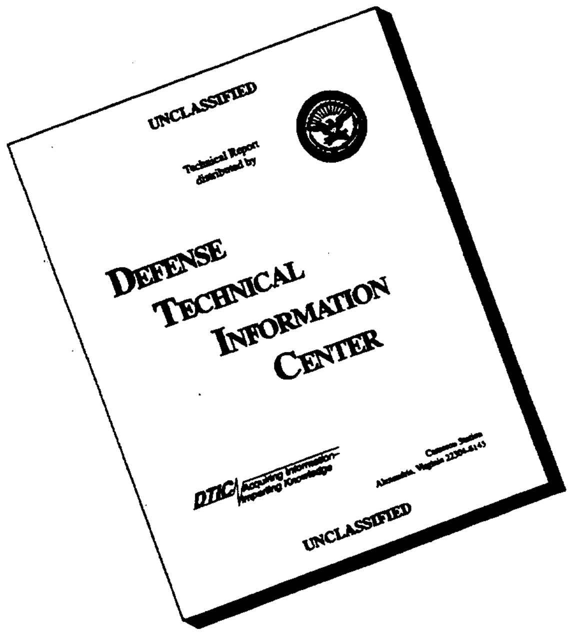
Phases I and II
Final Technical Plan
(Version 3.2)
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

FILE COPY

Environmental Science And Engineering, Inc.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
07/00/88

3. REPORT TYPE AND DATES COVERED
FINAL

4. TITLE AND SUBTITLE
BIOTA ASSESSMENT, PHASES I AND II, TASK 9, FINAL TECHNICAL PLAN, VERSION 3.2

5. FUNDING NUMBERS
DAAK1184D0016

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ENVIRONMENTAL SCIENCE AND ENGINEERIN

8. PERFORMING ORGANIZATION REPORT NUMBER
88243R05

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSERING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
NONE

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

THE BIOTA ASSESSMENT WILL FULFILL THE GENERAL NEED FOR COMPREHENSIVE INFORMATION ON THE PLANTS AND ANIMALS ON AND NEAR RMA IN RELATION TO CHEMICAL CONTAMINATION. THE PRIMARY OBJECTIVE OF TASK 9 IS TO PROVIDE INFORMATION ON:

1. MIGRATION OF CONTAMINANTS THROUGH THE FOOD WEB
2. INJURY TO ENVIRONMENTAL RESOURCES.

PHASE I INVOLVES THE COMPILATION OF EXISTING INFORMATION ON THE PRESENCE AND DISTRIBUTION OF RMA CONTAMINANTS IN THE BIOTA. A BRIEF FIELD SURVEY DOCUMENTS PRESENT CONDITIONS AND RECENT CHANGES. PHASE II CONSISTS OF ANY FIELD AND LABORATORY STUDIES NEEDED.

SECTIONS OF THE TWO TECHNICAL PLANS DETAIL INFORMATION ON THE FOLLOWING PROGRAMS: EVALUATION OF EXISTING INFORMATION, QUANTITATIVE BIOTA STUDIES, CHEMICAL ANALYSIS, QUALITY CONTROL, SAFETY, SAMPLING, AND DATA MANAGEMENT.

OTHER INFORMATION IN THE PLAN INCLUDES: CONTAMINATION SITES AND SOURCES, CONTAMINANTS OF CONCERN, CONTAMINANT LEVELS IN BIOTA, INJURIES AND DEATHS, FOOD WEBS, SPECIES LISTS.

14. SUBJECT TERMS
CHEMICAL INVENTORY, CONTAMINATION ASSESSMENT, CHEMICAL ANALYSIS, FLORA, FAUNA, SPECIES INVENTORY

15. NUMBER OF PAGES
(321)

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED			

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18

[redacted]

88243R05
2ND COPY

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Phases I and II
Final Technical Plan
(Version 3.2)
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Phase I Final Technical Plan
(Version 3.2)
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

SECTION I - PHASE I TECHNICAL PLAN
TABLE OF CONTENTS
(Page 1 of 2)

SECTION I - PHASE I TECHNICAL PLAN
TABLE OF CONTENTS
(Page 2 of 2)

SECTION I - PHASE I TECHNICAL PLAN
LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS
(Page 1 of 2)

AR	Army Regulation
CDOW	Colorado Division of Wildlife
CFI	Colorado Fuel and Iron Corporation
cm	centimeters
DA PAM	Department of Army Pamphlet
DARCOM	U.S. Army Materiel Development and Readiness Command
DBCP	Dibromochloropropane
DCPD	Dicyclopentadiene
DDT	Dichlorodiphenyltrichloroethane
DIMP	Diisopropylmethylphosphonate
DOJ	U.S. Department of Justice
EPA	Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
ft	feet
gal	gallon
Hyman	Julius Hyman and Company
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
in	inch
IR/DMS	Installation Restoration Data Management System
MKE	Morrison-Knudsen Engineers
OSHA	Occupational Safety and Health Act
PMO	Program Manager's Office
PPLV	Preliminary Pollutant Limit Value

LIST OF ACRONYMS
(Page 2 of 2)

QA	Quality Assurance
QC	Quality Control
RIC	Rocky Mountain Arsenal Information Center
RI/FS	Remedial Investigation/Feasibility Studies
RMA	Rocky Mountain Arsenal
Shell	Shell Chemical Company
USAMBRDL	U.S. Army Medical and Bioengineering Research and Development Laboratory
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USFWS	U.S. Fish and Wildlife Service
WWII	World War II

1.0 INTRODUCTION

1.1 DESCRIPTION OF THE RMA PROBLEM

The Rocky Mountain Arsenal (RMA) occupies over 17,000 acres (27 square miles) northeast of Denver, Colorado. RMA is immediately south of the city of Henderson, Colorado and directly east of Commerce City, Colorado in western Adams County (Figure 1.1-1). The South Platte River flows parallel to the northwest boundary and is less than 2 miles from RMA. RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982.

During the period from 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired 10.7 centimeter (cm) mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II (WWII) ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company (Hyman). CFI manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Hyman produced a variety of pesticides, including insecticides and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company (Shell) assumed the Hyman lease. Manufacturing by Shell ceased in 1982, but the Shell lease expires in 1987.

Construction of facilities for the production of GB nerve agent began in 1950 and was completed in 1953. Manufacture of GB was continued until 1957 and GB munitions filling operations continued until late 1969.

Basin A, whose boundary is contained within Section 36, was the original disposal area for waters and waste waters resulting from all RMA and industrial operations. Basin A was selected because it was part of a natural depression. In 1952, the impoundment dike was raised 5 feet (ft) to handle additional waste generated by opening of the GB plant. During

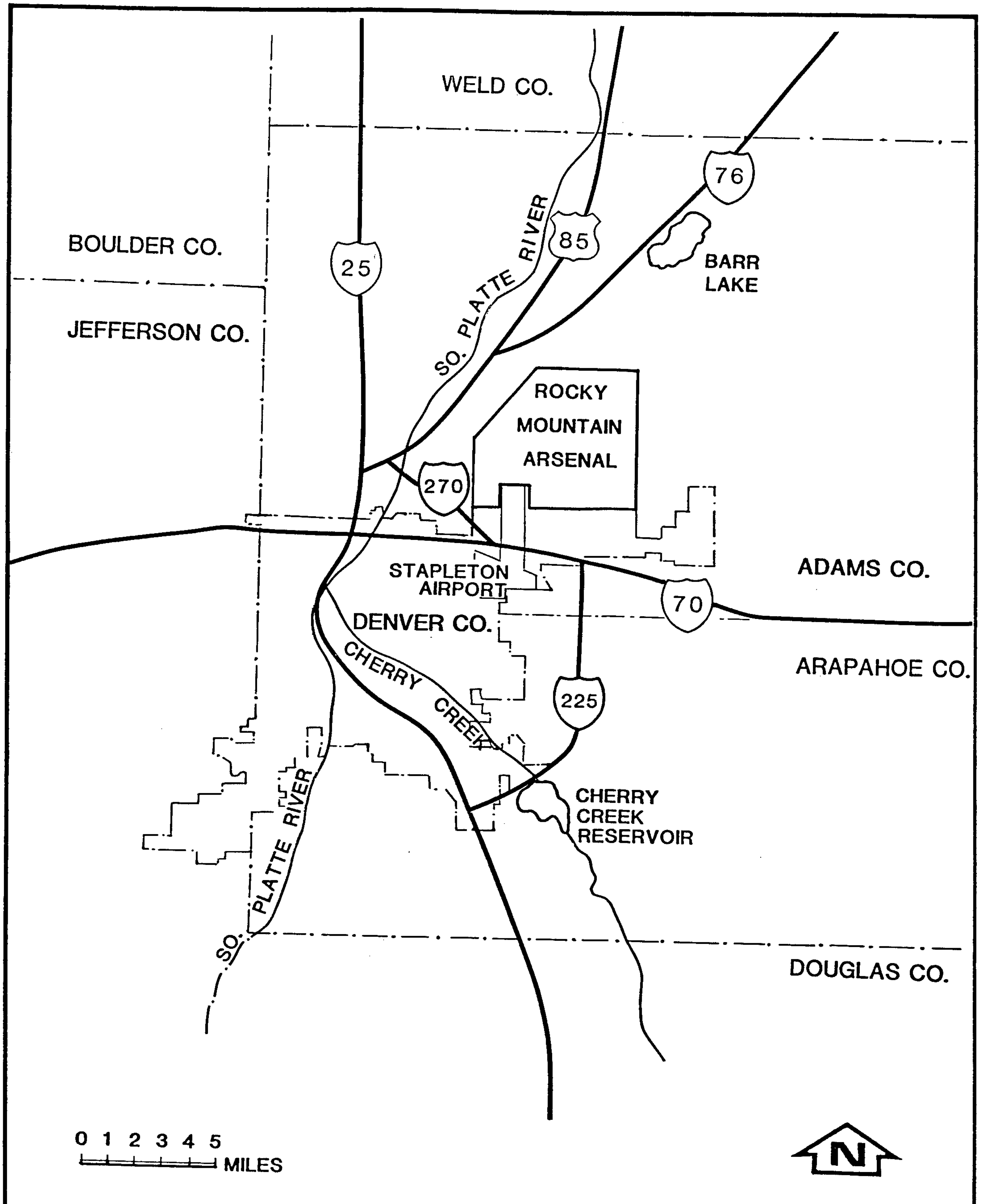


Figure 1.1-1
LOCATION MAP

SOURCE: RMA, 1983

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

the period from 1943 to 1956, Basin A was the primary receptor of liquid waste. Overflows went through the open drainage to Basins B, C, D, and E, constructed in 1952. Basin F was completed in 1957 to contain all waste waters, and liquids in Basin A were transferred to it by 1958.

During the period from 1965 to 1969, demilitarization of phosgene and cyanogen chloride munitions was performed at RMA. Disposal of mustard munitions occurred from 1972 to 1974, and demilitarization of GB munitions was performed from 1973 to 1976.

Disposal practices at RMA have included routine discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In addition to these practices, unintentional spills of raw materials, process intermediates, and final products have occurred within the manufacturing complexes at RMA. Many of these compounds are mobile in surface and ground waters as well as air.

Deaths and abnormal behavior have been recorded for several waterfowl species in the lower lakes on RMA (Jensen, 1955). Subsequent observation and testing indicated that ducks found dead, dying, or displaying unusual behavior (e.g., flying into buildings) contained high levels of dieldrin and other organochlorine compounds. Since that time, high levels of organochlorines have also been found in fish from the lower lakes, in raptors collected on and near the RMA, and in the flesh of other game animals including ring-necked pheasant, mourning dove, and cottontail rabbits.

Chemical analyses of fish and wildlife have been conducted on an annual basis from the early-1970's to the present. These studies have revealed that at least some of the waterfowl, fish, and other fauna from RMA contain levels of pesticides and metals (e.g., mercury) in their flesh which pose a potential health hazard to humans who consume them, and which could adversely affect wildlife by lowering reproductive success, decreasing hatching success of waterfowl, and causing the premature death of young individuals (U.S. Fish and Wildlife Service, 1980a).

In 1954 and 1955, farmers to the northwest of RMA reported severe crop losses due to use of well water for irrigation. Two contaminants, diisopropylmethylphosphonate (DIMP), which is a by-product of manufacture of GB nerve agent, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost ground water in 1974. Since 1974, offpost migration of dibromochloropropane (DBCP), a nematocide which had been shipped from RMA by rail from 1970 to 1975, has been observed in ground water.

Shallow ground water contamination exists in areas north and west of the RMA as a result of onpost activities.

1.2 REGIONAL BIOTA

Much of the land on RMA has been disturbed but remains in an undeveloped state. Shortgrass prairie and mixed grasslands predominate over much of the northern portion while lakes, wetlands, and small patches of woodlands are present along the southern section. Development of the area surrounding RMA for residential, commercial, and agricultural use have substantially modified the indigenous vegetation, thus RMA has become a haven for many wildlife species which do not occur in adjacent areas.

1.2.1 ONPOST BIOTA

There are several distinct vegetation types present on RMA which can be classified into three major ecosystem types: grassland, wetland, and aquatic. Most of the land area is grassland, but scattered thickets of small groves of trees are present along waterways and adjacent to buildings. Lakes, sloughs, and small watercourses are located in the southern portion of RMA. Wetlands are present adjacent to the lower lakes and around "the bog" situated along the northern boundary.

Detailed studies have recognized 25 vegetation communities on RMA in addition to areas of bare ground and manmade structures (Santa Barbara Remote Sensing Unit, 1978a, RIC#81286R08). Most of these are grasslands and shrublands which show varying levels of disturbance. Weed species are the dominant vegetation at many locations. Indigenous and introduced

plants on and near RMA are mostly common species which are widely distributed throughout the region.

Although native species dominate in some grassland areas, most areas have been disturbed in the past and contain introduced and weed species of grasses and forbs. These areas provide cover, food, and reproductive habitat for animal species such as mule deer, prairie dog, badger, coyote, ring-necked pheasant, mourning dove, and a variety of birds of prey such as burrowing owl, red-tailed hawk, and kestrel. Areas of woodland adjacent to wetlands and grassland habitat provide shelter and additional habitat for song birds, game birds, rodents, and deer.

Lakes and ponds, in the southern part of RMA, support populations of game fish including largemouth bass, bullhead, channel catfish, and bluegill. Fisheries in these lakes are the result of introductions and management (U.S. Fish and Wildlife Service, 1975, RIC#81286R02). Many species of waterfowl and shorebirds inhabit lakes and adjacent wetlands on RMA where they breed, forage, and/or stage in large numbers during periods of migration. Approximately half of the 27 species of ducks documented as inhabiting RMA are known to breed on and near RMA (Colorado Division of Wildlife, 1982b).

1.2.2 OFFPOST BIOTA

The area surrounding RMA is largely ranchland/farmland, rural residential, urban residential, and industrial (Kolmer and Anderson, 1977, RIC#81295R07). Irrigated crops are grown in the area northwest of RMA along the South Platte River. Much of the irrigation water is supplied from the river via a system of canals, but some areas are irrigated with shallow well water. The floodplain of the South Platte River, less than 3 miles northwest of RMA, contains scattered patches of wetland and mature stands of riparian woodland.

The adjacent land north of RMA consists mostly of rangeland (grassland) and dryland agriculture. Rural residential developments are scattered north and northwest of RMA. Urban developments include Commerce City

(west) and Montebello (south). The north runways of Denver's Stapleton International Airport extend into the southwestern corner of RMA.

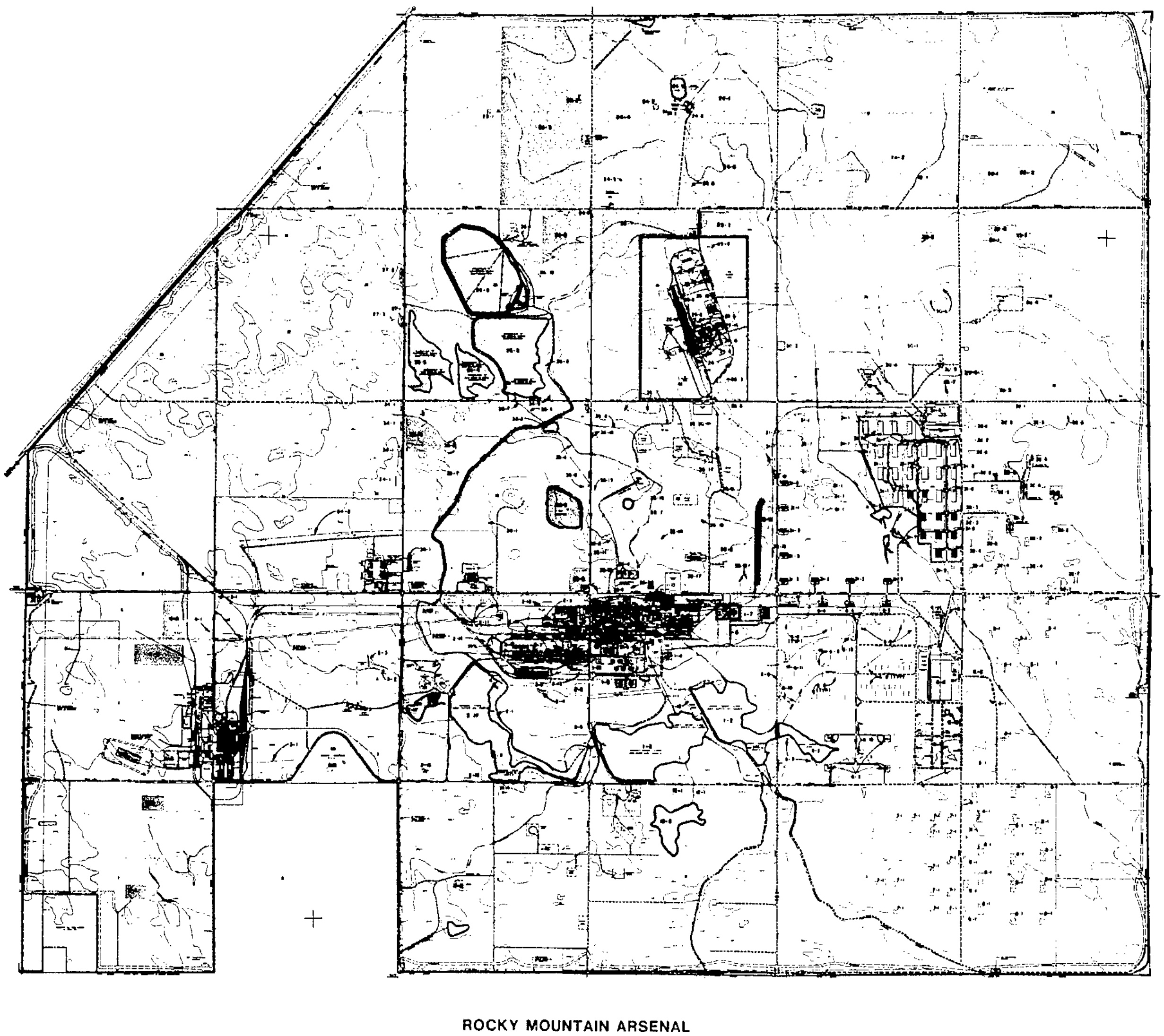
Cropland and range habitat north and east of RMA provide habitat for game species such as cottontails, ring-necked pheasants, and mourning dove. Lake and wetland areas at Barr Lake, 5 miles to the northeast and downstream from RMA, provide staging, breeding, and resting areas for waterfowl; habitat for edible fish species; and winter habitat for the bald eagle, an endangered species.

1.3 CONTAMINANT SITES AND SOURCES

Numerous potential contaminant sources and contaminant migration sources have been identified on the RMA (RIC, 1985). Many of these sites have the potential of adversely affecting plants, wildlife, and humans on and in the vicinity of RMA. Chemical contaminants in the soils, ground water, surface water, and lake sediments provide pathways for these chemicals to enter the biota and adversely affect individuals and populations in the plant and animal communities which comprise the major regional ecosystems.

A series of contaminant sources on RMA have been identified as the result of ground water flow studies and chemical analyses of soil and water. Many of the compounds identified as RMA contaminants can become incorporated into the biota, and many (e.g., organochlorine compounds) have known or suspected adverse affects (Hart, 1976, RIC#82161R06 and 1980, RIC#82005R02; O'Donovan and Woodward, 1977, RIC#81335R08; Palmer et al., 1979, RIC#81266R02). The presence of several of these compounds have been documented in plants and wildlife at RMA (Torgeson and Sirois, 1976; U.S. Fish and Wildlife Service 1952; U.S. Army Dugway Proving Ground, 1975a, RIC#84296R02; Cogley et al., 1979, RIC#81266R08; U.S. Fish and Wildlife Service, 1965, RIC#84296R04). Some of these compounds have been implicated in wildlife mortalities (U.S. Fish and Wildlife Service, 1952; U.S. Army Dugway Proving Ground, 1975c, RIC#85121R07).

Potential contaminant sites have been identified in 19 of the 28 sections or partial sections of land within the boundaries of RMA (Figure 1.3-1).



EXPLANATION

- Sites Likely to Contain Contaminated Materials
- Contaminated Sites Addressed Under Baseline Actions
- Balance of Areas Investigated

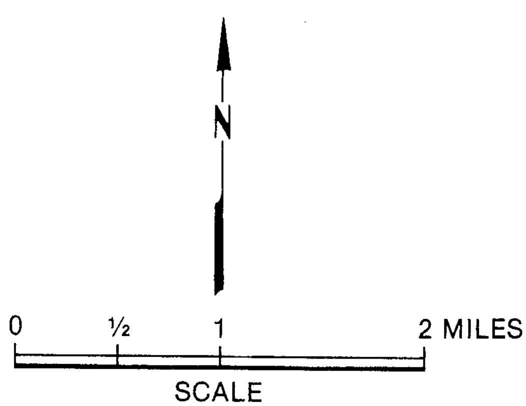


Figure 1.3-1
AREAS INVESTIGATED AS POTENTIAL CONTAMINATION SITES ON RMA

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal

Aberdeen Proving Ground, Maryland

Sources include a variety of locations and facilities such as chemical and sanitary sewers, unlined disposal pits and lagoons, burn pits, landfills, storage sheds, buildings, bomb disposal areas, chemical spill areas, surface drainage ditches, and lakes.

The major identified sources of contamination on RMA include Basin F (a lined liquid waste storage lagoon in Section 26), the South Plants area (including buildings, storage tanks, chemical and sanitary sewers, and chemical spill sites), and several discrete sites within Section 36. Basin A, a 120-acre site in Section 36, received wastes and by-products from most industrial processes at RMA and probably contains a broad variety of chemical compounds. Additional contaminant sources such as insecticide pits, lime pits, and burn areas also occur within Section 36.

The Lower Lakes on RMA (Lake Mary, Lake Ladora, Upper and Lower Derby Lakes, and the Rod and Gun Club Pond) located in Sections 1, 2, 6, and 12 in the southern portion of RMA also contain contaminated areas and are potential sources of contamination (USATHAMA, 1983, RIC#83326R01 and 1984, RIC#84034R01). Portions of these lake sediments either have been or still are contaminated with pesticides, primarily aldrin and dieldrin (Colorado State University, 1984, RIC#84142R01; U.S. Army Waterways Experiment Station, 1983).

Ground water studies have indicated that additional areas of chemical contamination north and west of the RMA are a result to some degree of the offpost migration of contaminated ground water (USATHAMA, 1984, RIC#84034R01). Additional information on the nature, extent, and concentrations of contaminants in ground water offpost is being gathered as part of the Offpost Contamination Assessment Program.

A total of 54 RMA related chemical contaminants are being analyzed in Phase I efforts on other tasks. The biological effects of some of these, such as the pesticides aldrin and dieldrin, are well known; however, the effects of exotic compounds related to the production of chemical weapons and rocket fuels are not well understood. Although the array of chemicals expected to be found at some sites is limited (e.g.,

organochlorine compounds and mercury in lake sediments), other sites have complicated histories of contamination and may contain dozens of different chemical contaminants (e.g., Basins A and F). The biota assessment of chemical contamination at RMA must, therefore, address the concentration, exposure pathways, and biological effects of each of these chemicals for each of the contaminated sites on and near RMA.

1.4 PAST BIOTA STUDIES

A substantial body of information on the presence and distribution of contaminants in RMA biota exists as a result of past investigations conducted since the mid-1950's (RIC, 1985). Many of these investigations have documented high levels of several contaminants in plants and in several species of wildlife.

Comprehensive studies of the vegetation included mapping the overall distribution of vegetation types on the RMA (Santa Barbara Remote Sensing Institute, 1978a, RIC#81286R08). Color-infrared aerial photography of RMA indicated that plant communities within known areas of contamination (e.g., near Basin F) exhibited stress. Some areas supported vegetation consisting of single stands of weedy species or were bare ground. Twenty-five plant community types and six non-vegetated cover classes were differentiated as a result of these studies.

Subsequent vegetation studies were conducted with the objective of monitoring movements of environmental contaminants on RMA (Santa Barbara Remote Sensing Institute, 1978b, RIC#81286R09). Research focused on three areas: 1) plant community studies, 2) remote sensing studies, and 3) literature surveys on the bioconcentration of RMA contaminants which might serve as biological indicators of contaminated areas. The study resulted in a suggested procedure which was apparently never implemented.

Soil samples from the coring program at RMA were tested for the presence of phytotoxic substances (Torgeson and Sirois, 1976; Cogley et al., 1979, RIC#81266R08). The phytotoxicity data did not indicate the presence of phytotoxins except in areas already known to be contaminated on the basis of chemical analyses of the soil samples. Section 36 was extensively

contaminated with phytotoxins generally present over approximately 100 acres. Adjacent portions of Section 35 had two sites showing phytotoxic contamination, and evidence of additional phytotoxicity were encountered in Sections 9, 22, 24, and 26. Most toxicants were found in the upper 2 ft of soil, occasionally in the horizon from 7 to 12 ft, and rarely below 12 ft.

Additional studies have been conducted on some of the chemical contaminants, particularly those which are peculiar to RMA activities, to determine the possible biological effects and concentrations necessary to produce effects (O'Donovan and Woodward, 1977, RIC#81335R08; Guenzi et al., 1979, RIC#81266R04; Palmer et al., 1979, RIC#81266R02; Hart, 1976, RIC#82161R06 and 1980, RIC#82005R02; Thake et al., 1979, RIC#81266R06). Although valuable information has been obtained, comparable types of information (e.g., dose levels, physiological effects, toxicity, mutagenicity, effects on reproduction, ability to produce physical abnormalities, etc.) for many suspected compounds of concern are still unavailable. Numerous studies of contaminant levels in plants, invertebrates, fish, and wildlife have been conducted since the early-1960's (Sheldon and Mohn, 1962: U.S. Fish and Wildlife Service, 1965, RIC#84296R04; U.S. Army Dugway Proving Ground, 1973 and 1975a, b, and c, RIC#84296R02, RIC#84296R03, and RIC#85121R07; U.S. Army Environmental Hygiene Agency, 1976, RIC#83020R03; Rocky Mountain Fisheries Consultants, 1977a, RIC#81286R07; Thorne, 1982, RIC#83042R01; U.S. Army Waterways Experiment Station, 1983; U.S. Army Rocky Mountain Arsenal, 1984).

Several fish species including northern pike, bass, rainbow trout, bullhead, channel catfish, and bluegill from the lower lakes on RMA were sampled for contaminants. Waterfowl from Basin F and from the lower lakes area were sampled on several occasions to determine levels of contaminants in their flesh. Although several compounds were present in detectable levels, the primary chemicals of concern for both fish and waterfowl were organochlorines associated with pesticide production (Sheldon and Mohn, 1962; U.S. Army Dugway Proving Ground, 1973; Thorne, 1982, RIC#83042R01). At least a few individuals of all the fish species sampled and all of the waterfowl, including 27 species of ducks found

dead or dying on RMA, were found to contain high levels of contaminants, primarily the pesticides aldrin and dieldrin.

Waterfowl losses associated with contaminated sites on RMA ranged from 2,000 to 3,000 individuals annually (U.S. Fish and Wildlife Service, 1960). Although scare devices have been installed at Basin F, waterfowl mortality figures are still about 200 to 250 individuals per year at that location (Thorne, 1983, RIC#85115R02). Dead and dying ducks and ducks exhibiting abnormal behavior as a result of chemical contamination (presumably from RMA sources) have been observed on Upper Derby, Lower Derby, and Ladora Lakes on RMA. Studies by the U.S. Fish and Wildlife Service have shown that resident ducks were the hardest hit by contamination. Ducks were observed to die of convulsions, fly with noticeable loss of equilibrium, and in several instances fly at full speed into the sides of buildings (U.S. Fish and Wildlife Service, 1952). One mallard, which died while showing lethal toxic signs at Lower Derby Lake, had 1.3 parts per million (ppm) endrin in the brain (U.S. Fish and Wildlife Service, 1982b). This is above the lethal level of 0.7-0.8 ppm for birds (Stickel et al., 1979).

Several additional wildlife species have been tested regularly for chemical contamination. The species sampled include cottontail rabbits, ring-necked pheasant, mourning dove, and occasionally mule deer. Control animals are obtained from an area several miles from RMA and are also analyzed for contaminants. Results consistently indicate that higher levels of contaminants are present in the flesh of animals found at selected locations near sites of contamination on RMA than from animals collected from offpost control areas (Thorne, 1982, RIC#83042R01).

The data from other studies conducted at RMA in the past also show high levels of organochlorines in diverse animals including spadefoot toads, great blue heron, starling, and red-tailed hawk (U.S. Army Dugway Proving Ground, 1973; U.S. Army Environmental Hygiene Agency, 1976, RIC#83020R03; Thorne, 1982, RIC#83042R01). A golden eagle which was shot near the edge of RMA contained 0.15 ppm dieldrin in breast muscle tissue and 1.7 ppm in

fat tissue. These levels are higher than those reported by Reidinger and Crabtree (U.S. Fish and Wildlife Service, 1982b).

Studies have been conducted on kestrels (sparrow hawks) by the Patuxent Wildlife Research Center of the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 1982b). Studies indicate that adverse effects on populations of these birds may be related to sites of contamination on RMA. Chemical analyses are being conducted and data prepared which should elucidate the relationship between these birds and RMA contaminants.

The levels of some contaminants (e.g., dieldrin, mercury) in the flesh of game animals and edible fish at RMA exceeds the Food and Drug Administration (FDA) action levels for animal and fish tissue (Food and Drug Administration, 1978, RIC#84338R01). The U.S. Fish and Wildlife Service has expressed concern to the Colorado Department of Health regarding the potential health hazard to humans (U.S. Fish and Wildlife Service, 1981). Concern has also been expressed by the Colorado Division of Wildlife over the movement of pheasants contaminated with pesticide residues off RMA onto private lands on the north and east sides of RMA where they can be hunted. These birds are reportedly contaminated above levels acceptable for human consumption (U.S. Fish and Wildlife Service, 1981).

Crude bioassay tests have been conducted on the aquatic ecosystem of the lower lakes which indicated that tadpole survival in water from Derby Lake was no different than the survival rate in the control; however, algae from Upper Derby Lake was sufficiently toxic to kill tadpoles within 2 weeks of exposure (Finley, 1959). Other data on bioconcentration of RMA contaminants exists which is consistent with generally known pathways of bioconcentration and bioaccumulation of organochlorine pesticides and other contaminants. Not much is known about the toxicity and environmental effects of several RMA contaminants.

1.5 SUMMARY OF TECHNICAL APPROACH

The biota assessment as described herein will fulfill the general need for comprehensive information on the plants and animals on and near RMA in relation to chemical contamination. The technical approach is designed to acquire and summarize existing information and to obtain any necessary additional information on the biota of RMA and the surrounding area. The primary objectives of this biota assessment are:

- To partially fulfill the U.S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study requirements for hazardous waste sites in accordance with National Contingency Plan;
- To provide specific information on the migration of contaminants through the local food web; and
- To provide information on injury to environmental resources which may be utilized in the forthcoming natural resource damage assessments for the onpost and offpost areas.

1.5.1 COMPATABILITY WITH OTHER RMA MONITORING PROGRAMS

Past investigations of the biota at RMA are discussed in Section 1.4 of this Technical Plan. Current studies by the Program Manager's Office (PMO) staff at RMA of the contamination in the fish and wildlife are scheduled to end prior to the implementation of any biota studies under this task. Close coordination has been initiated and will be maintained with the PMO staff at RMA to avoid duplication of effort and ensure the acquisition of pertinent litigation quality data.

The biota subtask of the Offpost Contamination Assessment Program is directed at determining the potential for movement of contaminants offpost via wildlife species which could pose a health hazard to humans. Work on this subtask presently involves trapping and radiotelemetry studies to determine the home range and seasonal movements of resident wildlife species, specifically cottontail rabbits and the ring-necked pheasant. Other potential effects of chemical contamination on the structure, components, and function of regional ecosystems are not considered.

Each of the other environmental tasks being conducted for the U.S. Army at RMA involves some level of contamination assessment for specific sources and/or locations on and in the vicinity of the RMA. This task assesses the damage by contamination on the biota for each of the locations/sources identified in other environmental tasks. Types of information which will be acquired include qualitative and quantitative information on the potentially affected biota, the effects of chemical contaminants on various components of the ecosystem (including important wildlife species such as game birds and fish), the determination of pathways of contaminant movement into the biota from regional sources (e.g., surface water, soil, etc.) and via the food web for each of the three major ecosystems present in the region, and continued investigation of the potential human health hazard via the biota pathway.

Close coordination and regular communication with other tasks and with the Morrison-Knudsen Engineers (MKE) wildlife biologists will be maintained in order to incorporate information relevant to the biota assessment and to avoid duplication of effort among concurrent investigations. Data on the distribution and concentration of RMA contaminants in the soils, ground water, and surface water which are being collected under Phase I of other RMA environmental tasks will be reviewed prior to the development of any field studies for the biota assessment.

1.5.2 SCOPE-OF-WORK

A comprehensive assessment of the flora and fauna on and near the RMA will be conducted in relation to the problem of RMA chemical contamination. The program of investigation will be performed in two phases. Phase I will essentially be a screening activity for the identification of important biotic species, contaminants of concern, contaminant locations/sources of interest, and contaminant pathways through major regional ecosystems. Phase II will focus on filling data gaps and on the acquisition of quantitative information on specific aspects of RMA contamination in relation to regional biota.

Phase I will involve the compilation of existing information on the presence and distribution of RMA contaminants in the biota. A brief field survey will be conducted to document existing conditions and note recent changes in the presence and distribution of plant and animal communities on RMA as part of this preliminary assessment process. Phase I will also involve the development of criteria for determining contaminant loadings on biota, identify data gaps, and subsequently produce a refined scope-of-work for any additional field studies which may be required in Phase II.

The contamination assessment portion of the Phase I studies will involve the development of several different data sets. A comprehensive food web will be constructed for each of the three major regional ecosystems (grasslands, wetlands, and freshwater aquatic) in order to provide a basis for determining potential pathways of movement for contaminants into the regional biota. Key contaminants of concern to biota will be refined on the basis of data acquired from the literature and from other environmental tasks. A list of plants and animals known to inhabit the RMA, including the identification of important species, will be developed.

Phase II will consist of any field and laboratory studies needed to address the overall objectives of the biota assessment for the Remedial Investigation. These studies would be based upon information acquired and evaluated during Phase I. Study design would rely heavily on the definition of contaminant sources and concentrations in soil, surface water, ground water, and man-made facilities obtained as a result of the Phase I portions of other RMA environmental studies. Any such studies would be coordinated with Phase II efforts of other environmental tasks.

Pertinent data on biological pathways, dose levels, and biological effects will be in reviewed conjunction with the activities of the "How Clean is Clean?" committee.

2.0 PHASE I: EVALUATION OF EXISTING INFORMATION

This phase will involve the compilation and evaluation of all pertinent information on biota in relation to RMA contaminants. Although much of this information has been developed in relation to specific contamination problems at the RMA, no single data base exists which includes current and historical information on species presence and abundance, contamination sources/locations, contaminant concentrations and distributions, biological effects, and other data pertinent to a comprehensive biota assessment. Current data on the distribution of vegetation types and recent disturbances are also needed and must be obtained from brief field surveys of the RMA and adjacent offpost areas. This information will be incorporated into a preliminary biota assessment consisting of several parts.

The focus of most studies of contamination in the biota at the RMA was largely to investigate the potential contamination pathways to humans via wildlife (e.g., mourning dove, cottontails, and mule deer) and edible fish (e.g., largemouth bass, catfish, and bullhead). Comprehensive studies on the movement of contaminants through the food webs on and adjacent to RMA and the potential impact on regional ecosytems have not been attempted. Studies of any secondary contamination of offpost biota, including vegetable crops and livestock exposed via contaminated ground water, are also lacking.

2.1 PRELIMINARY ASSESSMENT

The initial activity under Phase I will be a preliminary assessment of existing information from all available sources and a brief field survey of the RMA and vicinity to update information obtained from other sources. This preliminary assessment will result in the compilation of information from diverse sources in order to construct species lists, develop regional food webs, delineate sources/areas of concern, and identify biotic effects of contaminants as called for under the Phase I biota contamination assessment (Section 2.3).

2.1.1 STUDY AREA

For purposes of this assessment, the area defined for investigation includes all of the RMA and the study area for the Offpost Contamination Assessment, including Barr Lake and associated upstream surface waters (Figure 2.1-1). The offpost area has been defined on the basis of the distribution of potentially contaminated ground water, surface waters, and sediments which may provide sources of contamination for plant and animal species offpost. If review of existing information indicates this area should be expanded for investigation in Phase II, the appropriate revision will be incorporated into the draft Phase II Plan at the conclusion of Phase I studies.

2.1.2 REVIEW OF EXISTING INFORMATION

Numerous reports on the presence and concentration of contaminants in selected wildlife and fish species at the RMA have been accumulated since the mid-1950's. Most of these are available from the Rocky Mountain Arsenal Information Center (RIC) at the RMA. Additional studies conducted for the RMA and others which are published in the open literature provide information on the dose levels, biological effects, and pathways of movement for some of the chemical contaminants identified as present on the RMA. Information on the distribution, general population density, habitat affinities, and food habits of animal species is available from regional libraries and agencies. Current information on land uses surrounding the RMA, concentrations and distribution of contaminants in abiotic components of regional ecosystems (from Phase I portions of other environmental tasks), and acceptable methodologies for biota assessments at hazardous waste sites (presently being developed by the DOI for the EPA) are available from diverse sources. The RIC is a repository of materials relating to the RMA which presently contains over 1,400 items including: documents, maps, correspondence, news articles, and photographs relating the installation restoration program at the RMA. There are four card catalogs cross-referenced by title, performing organization, subject category, and study area. Newsletters and listings of all new documents are issued monthly. Relevant reference materials have been obtained from the RIC and will be incorporated into the biota assessment data base.

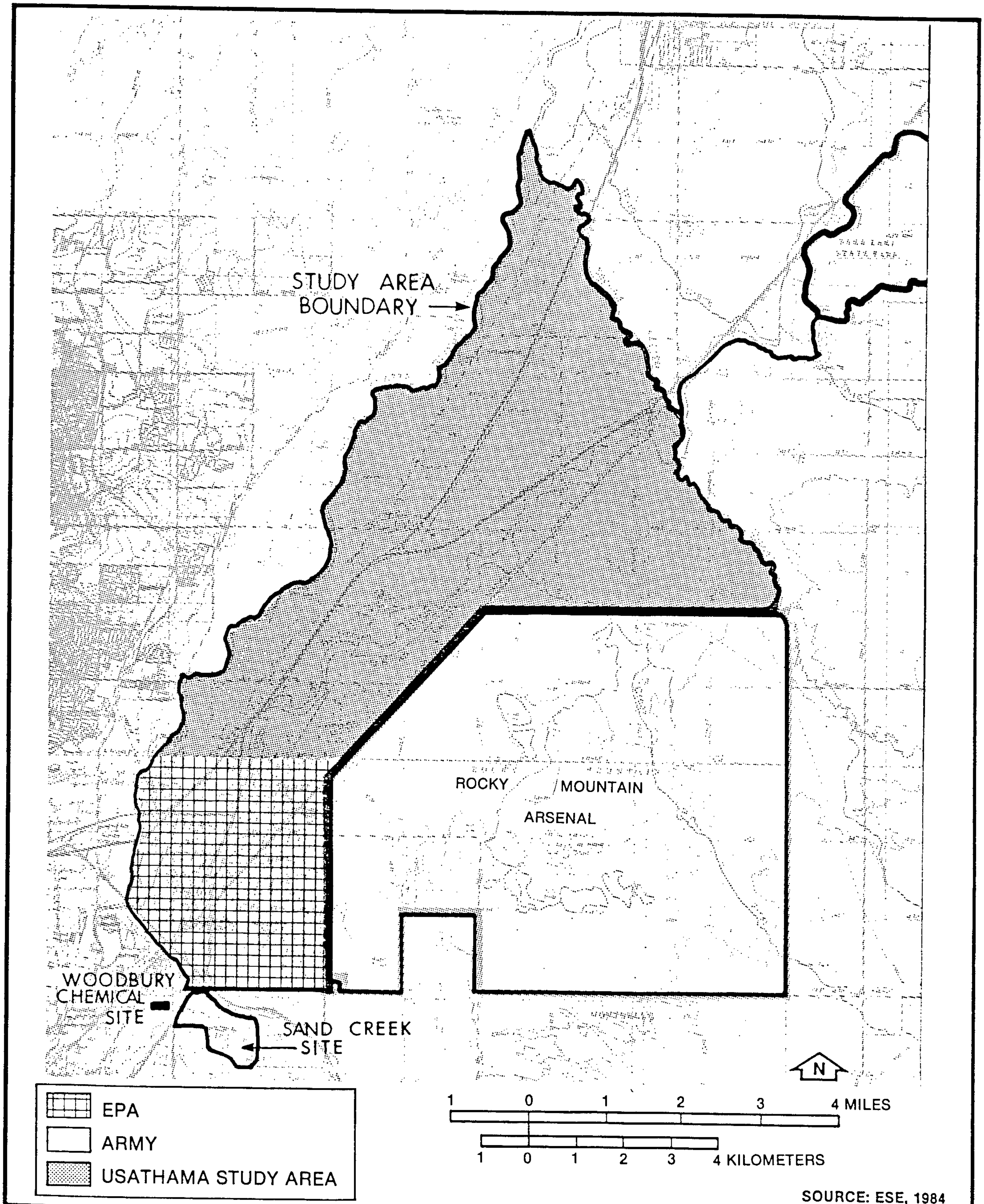


Figure 2.1-1
STUDY AREA BOUNDARIES

SOURCE: ESE, 1987

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

Over 180,000 documents have been accumulated that directly concern the RMA and have been examined in relation to the preliminary assessment. Because these information centers and the RIC are continuously being updated, it will be necessary to search each during the initial stages of the preliminary assessment and again just prior to preparation of the Phase I reports.

Several additional sources of information on regional biota will be investigated during the preliminary assessment. The U.S. Fish and Wildlife Service at the Denver Wildlife Research Center contains published information and reports on regional wildlife which will be used in evaluating the trophic status of important species in regional food webs.

A library of materials pertaining specifically to Colorado wildlife and environments is available at the headquarters of the Colorado Division of Wildlife (CDOW) in Denver, Colorado. The CDOW library contains maps showing the current distribution of important wildlife species. A computerized database contains additional specific regional information used to update the Latilong Series of publications which show the local distribution, habitat use, seasons of occurrence, and general abundance of vertebrate species. The library also houses special reports and annual updates of information pertinent to the biota on and near RMA. The library and supporting computer facilities will be regularly consulted throughout this phase to gather all available information relevant to the biota assessment.

The Patuxent Wildlife Research Center has conducted studies of the effects of pesticides on American kestrels (sparrow hawks) on and adjacent to the RMA. The studies are complete, but some reports are still in preparation. Copies of the draft reports should be available within the time frame of this preliminary assessment and should contain information directly concerning the effect of pesticide contaminants on biota at the RMA.

The Environmental Division at the RMA houses a collection of plant and animal specimens of species found on the RMA. Additional plant materials from studies conducted at the RMA are cataloged into the herbarium of Metropolitan State College in Denver, Colorado. Both of these collections and their respective curators will be consulted during the preliminary survey.

Other libraries which contain information on regional biota are: University of Colorado at Denver, Denver Public Library, University of Colorado at Boulder, and Colorado State University. Thesis and dissertation materials on regional wildlife species, vegetation types, and/or work conducted on the RMA are available only from these sources. These sources will be searched for information pertinent to the RMA biota assessment.

Additional sources of information either on regional biota or the organization of ecosystems may be present in other libraries or agency facilities identified in the course of acquiring information. Information on wildlife, domestic animals, and crops from questionaires currently being circulated to residents in the offpost study area by the Tri-County Health Department will also be incorporated into the database for biota assessment. If necessary, visits to these libraries will be made during the preliminary assessment phase with prior approval of the PMO.

It will be necessary to maintain periodic contact with the U.S. Army Medical and Bioengineering Research and Development Laboratory (USAMBRDL) and with some expert consultants throughout the course of this assessment to consult on information found and additional information needed, and to obtain assistance on locating specific types of information. Prior verbal and/or written authorization to make these contacts will be obtained from the PMO.

2.1.3 FIELD SURVEY

A brief field survey will be conducted within the study area to obtain pertinent information on the occurrence, distribution, and general

population density of key species of plants and animals. The distribution of major vegetative communities will be documented from aerial photography and ground-truthing visits to the area. Incidental observations on habitat disturbance, plant or animal mortalities, and general site conditions will be documented.

For purposes of this initial survey, key species are defined as:

- o Species which are listed as rare, threatened, or endangered either federally or by the State of Colorado;
- o Species of economic importance (e.g., game animals, furbearers, pests, etc.) including those species eaten by humans (e.g., ring-necked pheasant and cottontails);
- o Domesticated species eaten by humans (e.g., vegetable crops and livestock); and
- o Key species in regional food webs which may be directly affected by RMA contaminants or occur along key pathways of contamination movement through regional food webs.

The field survey will be completed prior to mid-November 1985. Although the time allocated for this work will not be extensive, surveys will encompass both the time period when vegetation is still available for easy identification (prefrost) and the fall migration period for waterfowl and other birds.

Limited vegetation inventories will be conducted to note major species composition in each vegetation type. It is anticipated that the detailed information on plant species which is currently being collected on RMA by MKE for Shell will be made available to ESE through the PMO for incorporation into Phase I Studies.

Field study methods for wildlife species will include driving and walking surveys of each major habitat type within the study area to note the presence of diurnally active species. Limited live trapping using small Sherman live traps (3 x 3 x 9 inches) and large Tomahawk live traps (9 x 9 x 32 inches) may be used at selected locations to trap small and medium sized mammals not easily detected by other methods. All animals

collected will be released uninjured. Documentation of important or unusual species will be made by photographs. Wildlife species occurrence will also be documented from observations of tracks and other sign (e.g., scat).

The existing information for most bodies of water within the study area suggest that no sampling will be necessary for fish, aquatic invertebrates, or vegetation in these areas (Thorne et al., 1979, RIC#81286R06; U.S. Army Dugway Proving Ground, 1975a and b, RIC#84296R02 and RIC#84296R03; Rosenlund et al., 1986, RIC#86041R02). It is anticipated that the data on aquatic species which will be obtained by MKE for Shell will also be made available for evaluation during Phases I and II.

Limited field visits will be conducted in areas of known or suspected contamination on the RMA. The biota field team members will not enter these areas without having the proper safety training and without wearing the proper safety equipment. No area under present environmental investigation will be entered without the prior notification of and approval by the Army or its designated contractor responsible for that area.

2.2 CRITERIA DEVELOPMENT

ESE will develop relevant criteria for the contamination loading of organisms, tissues, organs, etc. for key plant and animal species as defined in Section 2.1.3 of this Technical Plan. The development of these criteria will be accomplished through a review of pertinent literature and in consultation with USAMBRDL and appropriate expert consultants. Standards and methods for criteria which are currently being developed by the U.S. Fish and Wildlife Service (USFWS) will be incorporated as they become available (U.S. Department of Interior, 1985). This information will be used in determining potentially significant contaminant impacts on key plant and animal species, on the structure and function of regional ecosystems, and on humans on and near RMA.

The development of these criteria will be coincidental with the acquisition and review of all available information. Pertinent input from the "How Clean Is Clean?" committee will also be incorporated into the criteria development process. The Preliminary Pollutant Limit Value (PPLV) concept (Dacre et al., 1980; Rosenblatt et al., 1982, RIC#84125R01) will be applied for some animal species, contingent upon the availability of sufficient data. Although this approach has proven satisfactory for human use, its applicability to the biota has not been assessed. Additional field and laboratory study will probably be necessary in Phase II to obtain appropriate data for calculating PPLV's for most species.

Criteria development will incorporate the findings and methodologies currently being created by expert consultants for quantifying the transfer of contaminants between components of the abiotic environment and the biota. Methods for estimating the incorporation rates of contaminants from soil and water to plants, and for predicting the bioconcentration of chemical contaminants into key species of plants and animals are of particular interest.

2.3 CONTAMINATION ASSESSMENT

The assessment of contamination in regional biota constitutes the major portion of Phase I investigations. The principal objectives of the contamination assessment of biota are to provide specific information on the migration of RMA contaminants through the food webs of regional ecosystems and to partially fulfill the EPA Remedial Investigation/Feasibility Study (RI/FS) requirements for hazardous waste sites under the National Contingency Plan. Information obtained through this assessment will provide a basis for determining the extent of injury to the biotic resources on and near the RMA, assessing any damages, and developing methods of mitigating any damages which may have occurred to these resources.

The first phase of the contamination assessment of biota will focus on the accumulation and analysis of pertinent information in three main areas:

- The biological resources on and near the RMA;
- The presence, distribution, and concentration of contaminants in the abiotic environment (e.g., soil, surface water, ground water, and manmade facilities); and
- The effects of contaminants on various components and key species in regional ecosystems.

Information on the biota will be obtained primarily as a result of literature searches and contacts made as part of the Phase I preliminary assessment. Data on the chemical contaminants and their distribution are currently being obtained from other RMA environmental tasks and will be incorporated into the biota contamination assessment as they become available. Information on the effects of contaminants and their migration/concentration in biological systems will be obtained from literature sources, discussions with expert consultants, and contacts with authorities in the USAMBRDL. Effects which need to be addressed include death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, and physical deformations (U.S. Department of Interior, 1986).

The acquisition and analysis of available information will be used to identify any critical data gaps which exist with respect to the three categories mentioned above. A brief field survey will be conducted to verify and update information available from published and unpublished reports, maps, and aerial photography of the area. These data will be used to evaluate current conditions and to establish a basis for any future investigations which may be needed in Phase II.

The information required is diverse, complex, and probably insufficient for a detailed and comprehensive assessment of contamination effects on the structure, function, and components of biotic systems on and near the RMA. The initial phase of the contamination assessment will provide an integrated database of available information so that the assessment can be conducted and any critical gaps in the data can be identified. The following specific items will be developed in Phase I from this data base.

2.3.1 SPECIES INVENTORY

Species lists of plants and animals known to occur on and in the vicinity of the RMA will be compiled. Lists will identify those species of plants which are dominant in major ecosystems in the study area (e.g., grasslands, wetlands, and freshwater aquatic). A list of vertebrate animals, including native and introduced fish, which inhabit the area will also be developed. Species lists will indicate which species are resident, migratory, and/or breed in the area. Endangered, threatened, and game species (including edible fish species) will be indicated. Common and important invertebrates (e.g., pest species, those which are prey for game species, etc.) will be listed, based on information from regional publications and agencies and from the collections made on the RMA. These lists will be used in constructing food webs for regional ecosystems and for directly evaluating the actual and potential contamination effects.

Key species of plants and animals will ultimately be identified based on the following criteria:

- Species listed as federally threatened or endangered;
- Species which are important components of regional ecosystems (e.g., are abundant, are important predators or prey for key species);
- Species which are economically important (e.g., game species, crop pests);
- Species which are important to the structure and function of regional ecosystems;
- Species which have been designated as representative of a trophic level or guild by HEP methodology; and
- Species which are of a convenient size or otherwise appropriate for laboratory testing.

2.3.2 POPULATION DENSITIES

The general abundance of key species will be obtained from data gathered during the preliminary assessment portion of Phase I. This information will be used to provide a semi-quantitative basis for evaluating pathways

for the movement of contaminants into and among components of the plant and animal communities on and near the RMA.

2.3.3 FOOD HABIT STUDIES

Available data on the general food habits of key species inhabiting the RMA study area will be obtained from published literature and will provide a semi-quantitative basis for developing pathways of contaminant movement through regional food webs.

2.3.4 FOOD WEBS

Comprehensive food webs will be constructed for each of the three major ecosystems (grasslands, wetlands, and freshwater aquatic) on the RMA. Food web information will be organized in a database/spread sheet format on the IBM compatible computer system at ESE. Information on species occurrence, abundance, and food habits will be used. This arrangement will facilitate periodic updating as additional information becomes available. Computer storage of this material will permit analyses by individual food web components and/or compartments.

Food webs will be use to determine major pathways of potential contamination movement through the biota. Comprehensive food webs will provide an indication of which species and/or species assemblages (e.g., phytophagous insects) are involved in major pathways of regional ecosystems. Additional analyses can be conducted on individual species or compartments by examining the appropriate subweb of the comprehensive food web. Although quantitative data on the food habits of key animal species and detailed species lists are required for food web analysis, even incomplete data sets can lead to a functional understanding of the biological systems of an area and produce relevant data on the trophic organization of animal communities (Reagan et al., 1983).

The evaluation of food webs in relation to RMA contaminants will be performed on the comprehensive data sets. A "sink" food web can be created from the comprehensive food web data base which shows all pathways leading to a particular key species (Cohen, 1978; Pimm, 1982).

The species in this instance is a sink for materials moving upward through this particular subweb.

Contaminant migration can also be evaluated by creating "source" food webs, actually subwebs, which can display all pathways leading from particular contaminant sources. Each source can be evaluated by specified combinations of known or likely combinations of chemical contaminants. Once defined, these pathways can be submitted to detailed investigation using available data or by gathering additional pertinent information as necessary.

Analysis of the human "sink" food web will be developed in conjunction with the creation of other food webs. This web will include evaluation of pathways of contaminant transfer via wildlife (e.g., cottontail rabbits, pheasants, mourning dove, waterfowl), edible fish (e.g., largemouth bass, catfish, rainbow trout, northern pike), domestic crops (e.g., cabbage, melons, squash, etc.) and livestock (cattle, sheep, pigs) which are raised in the study area and consumed locally. This approach will be coordinated with the PPLV approach being developed by the "How Clean is Clean?" committee.

2.3.5 FIELD SURVEY

Information collected during the brief Phase I field survey will be used to augment published information, reports, maps, and aerial photography acquired as part of the preliminary assessment. Any significant differences between current and expected conditions of species and populations in the region in relation to past or present environmental conditions will also be documented.

2.3.6 CHEMICAL INVENTORY

A database of RMA chemical contaminants will be obtained. Available information on their biological activity and relevant properties will be developed and used to evaluate their effects on components of regional ecosystems. Information on dose-response levels will be incorporated as available. Current knowledge of existing literature indicates that basic information may be lacking for selected RMA contaminants; however, these

contaminants may not be present in significant concentrations and/or in locations which would pose a hazard to regional biota.

2.3.7 PHASE II SAMPLING SCHEME

The sampling scheme for Phase II will encompass biota studies for onpost and offpost areas. Food chains involving both wildlife and humans will be addressed. The scheme will include the description of any necessary field and/or laboratory studies including any required laboratory certification for evaluating contaminants in plant or animal species. Additional information on potential Phase II studies is presented in Section 3.0.

Materials gathered during Phase I studies will be evaluated to determine if available information is sufficient to address all aspects of the Biota Assessment. The comprehensive food web, data on chemical distribution and concentrations in the biotic environment, information on the biological effects of contaminants, and other materials produced during Phase I will be reviewed and used to identify critical data gaps to be addressed in Phase II.

Quantitative information will be required on contaminant levels in key species in relation to particular sources, exposure pathways for chemical contaminants of interest, and population densities of key species. Any additional studies will be predicated on the availability of appropriate data for the RMA and on the need for such information in relation to specific contaminant sources or key species identified in Phase I.

A detailed sampling scheme will be developed which incorporates all of the aforementioned elements, as necessary. Experimental (source) and control areas will be selected, the species and/or areas to be surveyed will be identified, the sampling design specified, and the protocol for laboratory procedures will be clearly indicated.

Final design of the Phase II sampling scheme will rely on data from the Phase I investigations of other environmental sampling tasks in order to determine which contaminants are present in which area and at concentrations which might produce direct or indirect adverse effects on the biota. Data for several key locations of probable concern (e.g., sites in Section 36) will become available by December 1985 in time to define sites which may require additional biota assessment studies. Areas which are presently thought to be of greatest concern include the sites in Sections 36, Basin F and surrounding areas, the lower lakes, and portions of the South Plants area. Data from other tasks, particularly those involving contaminant surveys in soils, will provide data to verify the absence of chemical contamination in areas on the RMA which may be selected as control areas for Phase II Biota Assessment investigations (e.g., Tasks 14 and 15 studies of Army sites in the peripheral areas of the RMA). Sufficient information from some of these tasks will not be available until the second quarter of 1986. Consequently, some Phase II investigations may be modified accordingly as these data become available.

3.0 PHASE II: QUANTITATIVE BIOTA STUDIES

Studies to be conducted in this phase are contingent on the need for additional information beyond that which already exists for biota in relation to chemical contamination at the RMA. The evaluation of existing documents, development of criteria, and completion of the various components of the contamination assessment in Phase I will be used to determine what, if any, additional studies are necessary. ESE will be prepared to conduct the Phase II Program with the prior approval of the PMO.

3.1 SCOPE-OF-WORK

A scope-of-work for Phase II cannot be defined until all pertinent information has been compiled and evaluated during Phase I. The complex interrelationships among biota elements and between biotic and abiotic components of the environment will result in the development of a correspondingly complicated approach. A scope-of-work which incorporates field sampling, laboratory studies, and chemical analyses may be needed during Phase II of the biota assessment. Potential studies which may be necessary include but are not limited to the following activities.

3.1.1 USE OF HABITAT EVALUATION PROCEDURES

Implementation of HEP for selected animal species may be part of Phase II investigations. HEP methodology is flexible, but generally involves a number of steps, generally divided into three phases: 1) preassessment activities, 2) baseline assessment, and 3) impact (e.g., damage) assessment.

Key species (evaluation species) for HEP are determined during the preassessment phase (Figure 3.1-1). Other preassessment activities include:

- Formation of an assessment team, usually involving a number of agency representatives;
- Delineation of study area boundaries (in this case, the onpost and offpost study areas plus other areas of potential effect determined during Phase I);

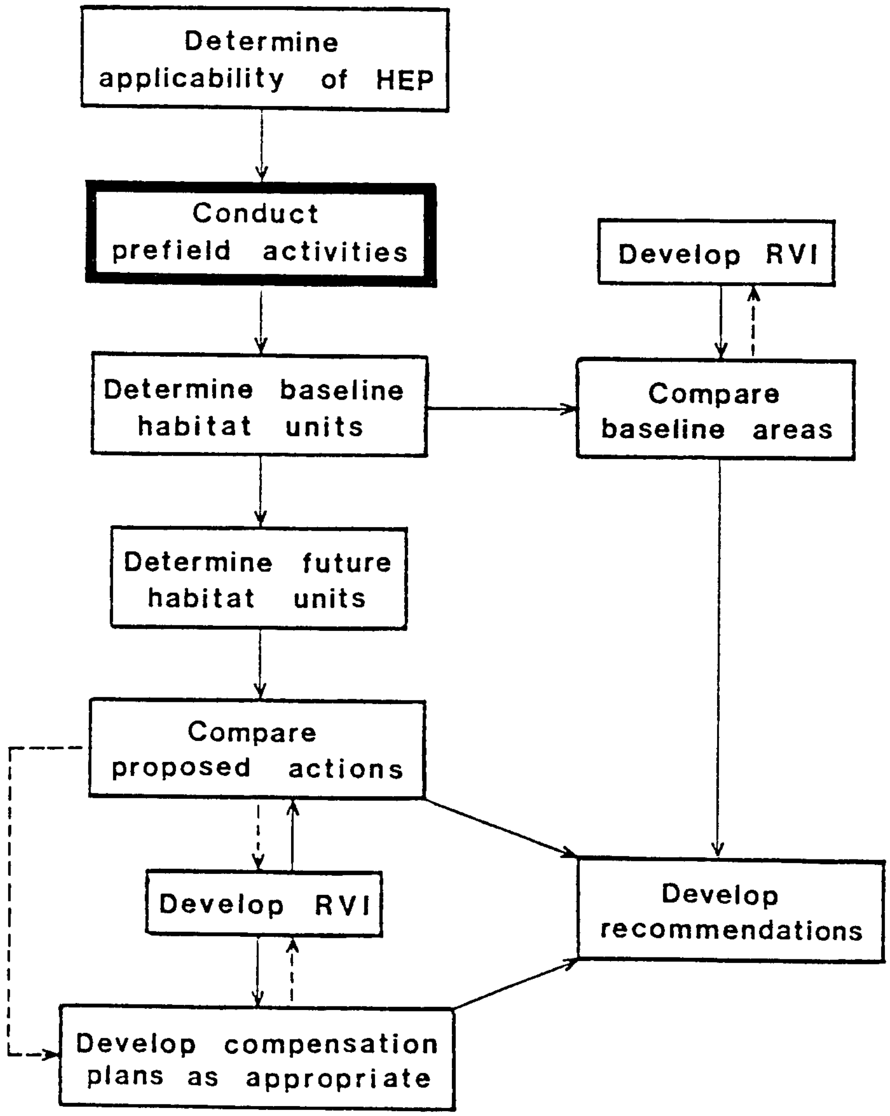


Figure 3.1-1
FLOW DIAGRAM OF HEP PROCESS, EMPHASIZING PREASSESSMENT ACTIVITIES
SOURCE: U.S. Fish And Wildlife Service, 1985

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

- o Assembly of available data (some additional data to supplement information compiled during Phase I may be required for selected species);
- o Delineation of cover types (information obtained from existing aerial photography and updated to current conditions);
- o Selection of evaluation species (based largely on data base for selection of key species during Phase I);
- o Selection of inventory techniques (based on HSI models existing and/or developed for evaluation species); and
- o Final development of sampling design.

The definition of the study area, compilation of most available data, and delineation of cover types will be accomplished during the preliminary assessment portion of the Phase I studies. Some adjustments to each of these may occur as a result of reevaluation by the HEP team. A major element of HEP is the selection of evaluation species. The process recognizes that it is not feasible or necessary to evaluate all species in an area, and incorporates guidelines for the selection of evaluation species. Most elements of this process will be used during the selection of key species in Phase I, but additional species may be selected if HEP is implemented during Phase II. Details of the species selection process for HEP are provided in the HEP Workbook (U.S. Fish and Wildlife Service, 1985) and presented in Appendix B.

3.1.2 FIELD STUDIES

Phase II field studies may include revisions and updating of land use/ cover types on and near the RMA with respect to identified sites of contamination. Maps would be created from existing information, recent aerial photography, and limited ground truthing. These maps would be necessary in evaluation of contaminant pathways and in the selection of experimental and control areas which may be required for field studies of contaminant effects and determination of injury/damages.

Additional field studies of key species, including domestic animals and crops in the offpost study area, may be necessary in order to quantify pathways of contamination movement and effects in regional ecosystems and

to humans via the biota pathways. Studies may include food habits, population densities, and ingestion rates. These studies will be in addition to any field investigations for HEP.

3.1.3 LABORATORY TESTING

Phase I studies may indicate important pathways of contaminants to key species or key compartments of regional ecosystems which have not been previously examined. Information on the effects of these concentrations of some contaminants, particularly those associated with RMA-specific activities may be needed in order to assess the biological effects of these chemicals. Determination of injury may include a variety of effects, not all of which are readily observable in the field. Possible effects include death, disease, behaviorial abnormalities, cancer, genetic mutations, physiologic malfunctions, and physical deformations.

Data on dose levels and effects for many potential contaminants (e.g., organochloride pesticides) is available in the open literature. Some additional data on specific compounds have been produced by the USAMBRDL in relation to RMA contamination. Review of existing information in Phase I will determine what, if any, additional testing may be required in Phase II.

3.1.4 CHEMICAL ANALYSES

Phase I studies for environmental tasks will define the presence, distribution, and concentrations of contaminants for the RMA. Phase I biota assessment studies will acquire information on the dose levels, pathways of movement, and levels of contaminants in selected biota. It is likely that additional chemical analyses will be required for key species identified as a result of Phase I. Additional areas of contamination which may present biological hazards may be identified. Selected species of these areas would need to be analyzed for selected contaminants in order to verify the nature and extent of actual or potential damage as required by proposed regulations (U.S. Department of Interior, 1985).

If these analyses are determined to be necessary, a certification program and sampling program will be instituted. These programs are discussed in Section 4.0.

3.1.5 CONTAMINATION ASSESSMENT

The objectives of this assessment are to evaluate the effects of RMA contaminants on the biota on and near the RMA. All pertinent available information will be used in an initial evaluation, and a determination of the adequacy of this information will be made prior to any Phase II biota assessment studies.

If it is determined that a Phase II Program will be necessary to obtain data for the contamination assessment, the work plan and subsequent technical plan for this program will contain detailed methodology regarding the species involved, locations of experimental and control areas, detailed procedures for collecting field data, and a detailed description of any chemical analyses, required certifications, and rationale for conducting additional studies. Additional data acquired from the Phase II programs of other environmental assessment tasks, particularly those dealing with the distribution and concentration of RMA contaminants in ground water and soils, will be obtained for incorporation into the final Biota Contamination Assessment.

The resulting contamination assessment for biota will provide a comprehensive assessment for ecosystems and key species on and near the RMA. The report will deal with specific sources of contamination on the RMA (e.g., Section 36, Lower Lakes, etc.) and in the offpost area so that the contamination assessment portions of reports for tasks involving these areas can incorporate pertinent biological assessment information. The combined work products from Phase I and II of this biota assessment program will be designed to fulfill the EPA's RI/FS requirements for a biota assessment and to provide appropriate information on biota for incorporation into the endangerment assessments. The necessary Safety Plan, Data Management Plan, and Chemical Analyses (including

certification) elements applicable to a Phase II program will be included in the draft Phase II program output from Phase I.

Close contact will be maintained with all other ongoing tasks at the RMA throughout the development of the Phase II work plan in order to obtain current information and to avoid potential duplications of effort among tasks. The draft Phase II work plan, developed as a result of Phase I biota assessment studies, will contain specific reference to present and anticipated Phase II work for all pertinent task investigations.

4.0 CHEMICAL ANALYSIS

The objective of the chemical analysis program is to provide the PMO with reliable, statistically supportable, and legally defensible chemical data regarding the type and level of contamination in selected components of the biota on and near the RMA. During the Phase I studies no chemical analyses will be done; however, historical chemical data on biological samples will be examined to identify possible data gaps with respect to contaminant levels in important species and/or potential important pathways of movement for areas of contamination at the RMA through regional food webs. Chemical analyses of the biota necessary to fill these data gaps will be performed during Phase II.

4.1 CERTIFICATION

Upon determination by the PMO that additional chemical analyses of the biota are needed, ESE will conduct a certification program on the tissue matrices of interest. The chemical analyses to be performed and tissues to be analyzed will be determined as a result of Phase I studies. Present information suggests that one or more specific chemical contaminants from the following groups may be involved: pesticides (organochlorine compounds), diisopropyl-methylphosphonate (DIMP)/dimethylmethylphosphonate (DMMP), DBCP, and extractable organics. Organosulfur compounds and their metabolites in biological systems and heavy metals may also be included, pending the results of Phase I investigations.

Certification for analysis of biological samples will involve methods development which may require substantial time and effort. Criteria development in Phase I and the identification of key species and data gaps will be given priority in order to determine what methods may need to be developed/certified so that certification can be initiated without unnecessary delay.

Methods for certification will be submitted to the Government under procedures defined in Task 1 (Contract No. DAAK11-84-D-0016). Upon approval of methods, certification will be conducted on those key

contaminants identified in the contamination assessment portion of this task as providing a "fingerprint" of contamination in the tissues and/or organisms to be analyzed.

4.2 SAMPLING PROGRAM

It is anticipated that some level of effort to obtain material for chemical analyses will probably be required for one or more chemical contaminants in one or more biotic species. Prior to sampling, a protocol will be developed for biota which is consistent with quality assurance procedures described in Section 5.0 of this document and in Section 5.0 of the Task 1 Technical Plan (Contract No. DAAK11-84-D-0016). The detailed design of this sampling program will be developed during Phase I.

5.0 QUALITY ASSURANCE

Quality Assurance (QA) for Task 9 will be consistent with the Field/Laboratory QA Plan developed for Task 1 activities. The plan is project specific and describes procedures for controlling and monitoring sampling and analysis activities as required under Task 9. As designed, the Field/Laboratory QA Plan will ensure the proper production of valid and properly formatted data concerning the precision, accuracy, and sensitivity of each method used for the PMO sampling and analysis efforts. The plan is based on USATHAMA April 1982 QA program requirements and modifications, and complies with ESE policy. The plan is presented in Appendix B of the Task 1 Technical Plan. Specific RMA QA and Quality Control (QC) requirements are detailed in Section 5.0 of the same document.

6.0 DATA MANAGEMENT PLAN

Data from Task 9 studies will be handled according to the Data Management Plan in Volume I of the Task 1 Technical Plan, Contract Number DAAK11-84-D-0016. As outlined in the plan, field data will be entered into a personal computer in ESE's Western Regional Office in Denver, Colorado, and transmitted via telephone to the computer system in ESE's home office in Gainesville, Florida. The field data will then be transferred to the Installation Restoration Data Management System (IR-DMS) as appropriate.

Biota samples for chemical analyses will be processed by the same handling procedures described for Task 1. Sample number assignments, labels, and logsheets will be made in the ESE Gainesville laboratory and sent to the sampling team. Samples shipped to ESE will follow the chain-of-custody procedures described in the Task 1 Technical Plan. Data from lab analyses will be entered into the Prime 750 computer in ESE Gainesville, incorporated with certification and field data, and formatted into files according to the IR-DMS User's Guide. After validation, these files will be sent to the Univac computer system in Aberdeen Proving Ground, run through the data checking routine, and elevated to Level 2.

7.0 SAFETY PROGRAM

The purpose of this section is to summarize the safety, accident, and fire protection standards, and to outline standard operating procedures to ensure the safety of all personnel performing Task 9 activities. Responsibilities, authorities, and reporting procedures for Task 9 are identical to those designed for Task 1 in Section 7.0 of the Task 1 Technical Plan.

The program addresses all of the requirements of DI-A-5239B and fully complies with the requirements of the Occupational Safety and Health Act (OSHA) and U.S. Army Materiel Development and Readiness Command (DARCOM) Regulation 385-100, Army Regulations (AR) 385-10, and Department of the Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

7.1 WASTE CHARACTERISTICS

In the 40 year history of the RMA, many extremely hazardous chemicals were manufactured, stored, or partially destroyed in demilitarization activities. Key compounds include GB nerve agent, H and L blister agents, munitions, organophosphorus pesticides and herbicides, hydrazine, and toxic metals. A comprehensive list of contaminants of concern is given in Table 7.1-1. Detailed information on many of these compounds is given in Agent Fact Sheet, SMCRM Form 357 (RMA, 1984) and Military Chemistry and Chemical Agents, TM 3-215 and AFM 355-7 (U.S. Army and U.S. Air Force, 1963, RIC#84221R01). Copies of this information will be available at the ESE support trailer at the RMA.

7.2 GENERAL PROCEDURES

Known and potential areas of contamination at or near the RMA are presently being studied under the various contamination assessment tasks being conducted on soils, ground water, and bodies of surface water/sediments in relation to RMA contaminants for the PMO. The

Table 7.1-1. Contaminants of Concern at the RMA (Page 1 of 2)

Organic Contaminants

Ethylbenzene

Benzene

Aldrin

Endrin

Dieldrin

Isodrin

Dibromochloropropane (DBCP)

Malathion

Parathion

Methylisobutylketone (MIBK)

Chlorophenylmethylsulfide (CPM Sulfide)

Chlorophenylmethylsulfoxide (CPM Sulfoxide)

Chlorophenylmethylsulfone (CPM Sulfone)

Dicylcopentadiene (DCPD)

Hexachlorocyclopentadiene (HCCPD)

Chlordane

Azodrin

Supona

Bicycloheptadiene (BCHD)

p,p-DDT

p,p-DDE

Atrazine

Dimethyldisulfide (DMDS)

Vapona

Table 7.1-1. Contaminants of Concern at the RMA (Continued, Page 2 of 2)

Organic Contaminants (Continued)
Chloroform
Diisopropylmethylphosphonate (DIMP)
Dimethylmethylphosphonate (DMMP)
Dithiane
1,4-Oxathiane
1,1-Dichloroethane
1,2-Dichloroethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Carbon tetrachloride
Methylene chloride
trans-1,2-dichloroethylene
Toluene
Xylenes (o-, m-, p-)
Chlorobenzene
Tetrachloroethylene
Trichloroethylene
Inorganic Contaminants
Zinc (Zn)
Copper (Cu)
Chromium (Cr)
Cadmium (Cd)
Lead (Pb)
Arsenic (As)
Mercury (Hg)

Source: ESE, 1984

technical plan for each of these tasks contains an approved safety plan for work in these areas.

All and any biota sampling which involves entering these areas of known or suspected contamination will be conducted by ESE personnel who have the appropriate level of safety training for work in these areas. All pertinent safety procedures for work within hot zones will be strictly followed. These areas of known or potential contamination will be entered only after prior permission has been obtained from the safety officers of the sites to be investigated. Work in these areas is not anticipated for the brief field investigation to be conducted in Phase I. It is anticipated that only limited work (e.g., mammal trapping, vegetation sampling, etc.) will be necessary in such areas during the proposed Phase II sampling program.

8.0 CONTAMINATION ASSESSMENT

The Contamination Assessment will be conducted under the two program phases described in Section 2.0 and 3.0 of this Technical Plan. A Preliminary Assessment will be prepared in Phase I and included as an output of this Phase. If additional studies are necessary in Phase II to fill data gaps, the Preliminary Contamination Assessment will be revised accordingly and produced at the end of Phase II.

BIBLIOGRAPHY

Burchfiel, J.L., Duffy, F.H., and Simm, V.M. 1975. Persistent Effects of Sarin and Dieldrin Upon the Primate Electroencephalogram. Department of Army, Aberdeen Proving Ground, Maryland. RIC#84276R02.

Cogley, D.R., Craker, L.E., Torgeson, C.D., and Sirois, D.L. 1979. Biological Testing of Rocky Mountain Arsenal for Phytotoxic Substances, Final Report. Wilmington, Massachusetts. RIC#81266R08.

Cohen, J.E. 1978. Food Webs and Niche Space. pp. 189. Princeton University Press, Princeton, New Jersey.

Colorado Division of Wildlife. 1981a. Colorado Divison of Wildlife Internal Correspondence to Jack Grieb from John Seidel. Regarding Pheasant Contamination at Rocky Mountain Arsenal.

Colorado Division of Wildlife. 1981b. Colorado Reptile and Amphibian Distribution Latilong Study. 2nd Edition. Nongame Section, Colorado Division of Wildlife, Denver, Colorado.

Colorado Division of Wildlife. 1982a. Colorado Mammal Distribution Latilong Study. Colorado Division of Wildlife, Denver Colorado.

Colorado Division of Wildlife. 1982b. Colorado Bird Distribution Latilong Study. Colorado Division of Wildlife, Denver, Colorado.

Colorado State University. 1984. Sediment Investigations in Lower Derby and Ladora Lakes. Final Report, April 1984. RIC#84142R01

Dacre, J.C., Rosenblatt, D.H., and Cogley, D.R. 1980. Preliminary Pollutant Limit Values for Human Health Effects. In: Environmental Science and Technology, 14:778.

Directorate of Installation Restoration. 1976. Methodology for Ecological Monitoring of Pesticides, Heavy Metals, and Other Contaminants at Rocky Mountain Arsenal. Department of the Army. Rocky Mountain Arsenal, Denver, Colorado. RIC#81281R21

Dost, F.N., Reed, D.J., and Wang, C.H. 1968. Inorganic Fluoride Propellant Oxidizers. Volume II. Effects Upon Microorganisms, Fish, and Plants. Oregon State University, Corvallis, Oregon.

Environmental Protection Service. 1975. Methods for Testing Effects of Chemicals on Birds. Environment, Canada Report EPS 1-EC-75-1.

Finley, R.B. 1959. Investigations of Waterfowl Mortality at the Rocky Mountain Arsenal. Internal U.S. Fish and Wildlife Service Report, Denver Wildlife Research Center.

Food and Drug Administration. 1978. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Food. Washington, D.C. RIC#84338R01.

Guenzi, W.D., Beard, W.E., Bowman, R.A., and Olsen, S.R. 1979. Plant Toxicity and Soil Transformations of Soil Incorporated Sulfur Compounds. Final Report. RIC#81266R04.

Hart, E.R. 1976. Mammalian Toxicological Evaluation of DIMP and DCPD. Final Report. RIC#82161R06.

Hart, E.R. 1980. Mammalian Toxicological Evaluation of DIMP and DCPD (Phase 2). Final Report. RIC#82005R02.

Jensen, W.I. 1955. Waterfowl Mortality, Rocky Mountain Arsenal, Summary Report. Denver, Colorado. RIC#84292R04.

Kolmer, J.R. and Anderson, G.A. 1977. Installation Restoration of Rocky Mountain Arsenal, Part I-Pilot Containment Operations. Final Environmental Impact Statement. DOA. RIC#81295R07.

Maugh, II, T.H. 1984. Tracking Exposure to Toxic Substances. Science 226:1183-1184.

Mecler, F.J. 1981. Mammalian Toxicological Evaluation of DIMP and DCPD (Phase 3-IMPA). Final Report. Litton Bionetics, Inc. Kensington, Maryland. RIC#82327R02.

O'Donovan, P.A. and Woodward, J.E. 1977. Investigations of the Environmental Fate and Phytotoxicity of DIMP and DCPD. Final Report. RIC#81335R08.

Odum, E.P. 1971. Fundamentals of Ecology, Third Edition. W.B. Saunders Company, Philadelphia, Pennsylvania.

O'Shea, T. and Ludke, J.L. 1979. Monitoring Fish and Wildlife for Environmental Pollutants. U.S. Fish and Wildlife Services. Washington, D.C.

Pacific Northwest Laboratory. 1984. Characterization of Chemical Waste Site Contamination and Its Extent Using Bioassays. Battelle Memorial Institute. RIC#85112R01.

Palmer, J.D., Cysewski, S.J., Crookshank, H.R., Steel, E.G., and Ivie, G.W. 1979. Toxicologic Evaluation and Fate of Diisopropyl-methylphosphonate (DIMP) in Cattle. USDA. College Station, Texas. RIC#81266R02.

Pimm, S.L. 1982. Food Webs. Chapman and Hall, London.

Reagan, D.P., Garrison, R.W., and Waide, R.B. 1983. Preliminary Evaluation of Trophic Structure in a Puerto Rican Rain Forest. Proc. Octavo Symposio de los Recursos Naturales, San Juan, Puerto Rico.

Rocky Mountain Arsenal (RMA). 1984. Agent Fact Sheet, SMCRM Form 357.

Rocky Mountain Arsenal Information Center (RIC). 1985. RIC Catalog. D.P. Associates, Rocky Mountain Arsenal Information Center, Commerce City, Colorado.

Rocky Mountain Fisheries Consultants, Inc. 1977a. Preliminary Aquatic Survey, Rocky Mountain Arsenal, Commerce City, Colorado. Rocky Mountain Arsenal Information Center, Commerce City, Colorado. RIC#81286R07.

Rocky Mountain Fisheries Consultants, Inc. 1977b. Primary Productivity Estimates in Lower Derby and Ladora Lakes. Ft. Collins, Colorado. RIC#85115R03.

Rosenblatt, D.H., Dacre, J.C., and Cogley, D.R. 1982. An Environmental Fate Model Leading to Preliminary Pollutant Limit Values for Human Health Effects. In: Environment Risk Analysis for Chemistry. Chapter 15. RIC#84125R01.

Rosenlund, B., Jennings, D., Kurey, W., Jackson, T., and Bergeson, E. 1986. Contaminants in Aquatic Systems at the Rocky Mountain Arsenal, 1984. U.S. Fish and Wildlife Service, Denver, Colorado. RIC#86041R02.

Santa Barbara Remote Sensing Unit. 1978a. Vegetation Map of Rocky Mountain Arsenal, Commerce City, Colorado. RIC#81286R08.

Santa Barbara Remote Sensing Unit. 1978b. Monitoring Movement of Environmental Contaminants through Ecological Studies at the Rocky Mountain Arsenal, Commerce City, Colorado. University of California at Santa Barbara, Santa Barbara, California. RIC#81286R09.

Sheldon, M.G. and Mohn, M.H. 1962. Evaluation of Local Pesticide-Wildlife Problems in the Western United States.

Stickel, W.H., Reichel, W.L., and Hughes, D.L. 1979. Endrin in Birds: Lethal Residues and Secondary Poisoning. pp. 397-406. In: Toxicology and Occupational Medicine, Elsevier, New York.

Thake, D.C., Mays, D., Leber, P., Metcalf, D., and Bavada, L. 1979. Mammalian Toxicological Evaluation of p-Chlorophenylmethylsulfide, p-Chlorophenylmethylsulfoxide, and p-Chlorophenylmethylsulfone. Final Report. RIC#81266R06.

Thomas, J.M., Cline, J., Cushing, C., Rogers, J. 1983. Field Evaluation of Hazardous Waste Site Bioassessment Protocols, Vol. I and II. Pacific Northwest Laboratories. RIC#84188R01.

Thorne, D.S. 1982. Contaminants in Fish and Game Animals on Rocky Mountain Arsenal 1977-1982. Rocky Mountain Arsenal Information Center, Commerce City, Colorado. RIC#83042R01.

Thorne, D.S. 1983. Quarterly Reports on Mortality of Waterfowl on Basin F, January 1981-June 1983. RIC#85115R02.

Thorne, D. S., McBride, J.K., Legros, C.R., Ells, J.O., and Manlove, M.S. 1979. Biological Monitoring of Pesticides, Heavy Metals, and Other Contaminants at Rocky Mountain Arsenal. Department of the Army, Commerce City, Colorado. RIC#81286R06.

Torgeson, C. and Sirois, D.L. 1976. Report 1 Survey of the Rocky Mountain Arsenal for Phytotoxic Substances. Final Comprehensive Report. Boyce Thompson Institute. RIC#81341R02.

U.S. Army and U.S. Air Force. 1963. Military Chemistry and Chemical Agents, TM 3-215 and AFM 355-7. RIC#84221R01.

U.S. Army Dugway Proving Ground. 1973. Incident Report on the Wildlife Mortalities at Rocky Mountain Arsenal During the Period April 4 through June 14, 1973. Dugway, Utah. RIC#84131R02.

U.S. Army Dugway Proving Ground. 1974. Preliminary Environmental Survey of Rocky Mountain Arsenal, Denver, Colorado. Interim Report. Dugway, Utah. RIC#81324R30.

U.S. Army Dugway Proving Ground. 1975a. Interim Report on Pesticide Levels in Fish from Two Industrial Lakes at Rocky Mountain Arsenal. Dugway, Utah. RIC#8429R02.

U.S. Army Dugway Proving Ground. 1975b. Interim Report on Pesticide Levels in Fish Collected March 20, 1975 from Lake Ladora at Rocky Mountain Arsenal. Dugway, Utah. RIC#84296R03.

U.S. Army Dugway Proving Ground. 1975c. Second Interim Summary Report of Dugway's Findings on the Causes of Waterfowl Mortalities in and Around Reservoir F at Rocky Mountain Arsenal. Dugway, Utah. RIC#85121R07.

U.S. Army Dugway Proving Ground. 1977. Baseline Ecological Survey of Selected Small Mammals on Rocky Mountain Arsenal, Denver, Colorado. Dugway, Utah. RIC#81321R01.

U.S. Army Dugway Proving Ground. 1979. Handbook for Evaluating Ecological Effects of Pollution at DARCOM Installations. Vol. 6. Unexpected Declines in Animal Populations. Dugway, Utah. RIC#82161R07.

U.S. Army Environmental Hygiene Agency. 1973. Small Animal Deaths - Rocky Mountain Arsenal, Denver, Colorado, May through August 1973. Special Study No. 99-055-73/74. Aberdeen Proving Ground, Maryland. RIC#85107R01.

U.S. Army Environmental Hygiene Agency. 1976. Rocky Mountain Arsenal Bird Kill. Entomological Special Study No. 44-123-76. Aberdeen Proving Ground, Maryland. RIC#83020R03.

U.S. Army Rocky Mountain Arsenal. 1984. Chemical Monitoring of Fish and Game Animals on Rocky Mountain Arsenal. Denver, Colorado.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1983. Selection of a Contamination Control Strategy for Rocky Mountain Arsenal. Vol. and II. U.S. Army, Aberdeen Proving Ground, Maryland. RIC#83326R01.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1984. Decontamination Assessment for Land and Facilities at Rocky Mountain Arsenal. U.S. Army, Aberdeen Proving Ground, Maryland. RIC#84034R01.

U.S. Army Waterways Experiment Station. 1983. Lake Ladora and Lake Mary Sediment Contamination Survey. Preliminary Screening Report. Vicksburg, Massachusetts.

U.S. Department of Interior. 1985. Natural Resource Damage Assessments. Draft. Washington, D.C.

U.S. Fish and Wildlife Service. 1952. Letter correspondence to Rocky Mountain Arsenal, June 4, 1952. Denver, Colorado.

U.S. Fish and Wildlife Service. 1960. Letter correspondence to Rocky Mountain Arsenal, February 26, 1960.

U. S. Fish and Wildlife Service. 1965. Movement and Accumulation of Aldrin in Lakes at the Rocky Mountain Arsenal, Colorado in Relation to Waterfowl Losses. Denver Wildlife Research Center, Denver, Colorado. RIC#84296R04.

U.S. Fish and Wildlife Service. 1975. Fishery Management Program, Rocky Mountain Arsenal, Aurora, Colorado. Special Project Report. U.S. Department of Interior. Vernal, Utah. RIC#81286R02.

U.S. Fish and Wildlife Service. 1980a. Letter correspondence to Colorado Department of Health. Denver, Colorado.

U.S. Fish and Wildlife Service. 1980b. Letter correspondence to Colorado Department of Health, 1980. Denver, Colorado.

U.S. Fish and Wildlife Service. 1981. Letter correspondence to Colorado Department of Health, December 23, 1981. Fort Collins, Colorado.

U.S. Fish and Wildlife Service. 1982a. Chemical Contaminant Residues and Effects on Kestrels and Other Wildlife of the Colorado Rocky Mountain Arsenal. Progress Report, Part I.

U.S. Fish and Wildlife Service. 1982b. Letter correspondence to Rocky Mountain Arsenal, April 14, 1982. Fort Collins, Colorado.

U.S. Fish and Wildlife Service. 1985. Habitat Evaluation Procedures Workbook. HEP Group. Western Energy Land Use Team, U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Williams, J. 1981. Vegetation Studies at Rocky Mountain Arsenal. Thorne Ecological Institute. Boulder, Colorado.

APPENDIX A

HABITAT AS A BASIS FOR ENVIRONMENTAL ASSESSMENT

Habitat as a Basis for Environmental Assessment

101 ESM

Division of Ecological Services
U.S. Fish and Wildlife Service
Department of the Interior
Washington, D.C.

Preface

Since 1974, the U.S. Fish and Wildlife Service (USFWS) has been developing a habitat-based evaluation methodology entitled the Habitat Evaluation Procedures for use in impact assessment and project planning. This work has lead to the development of a series of documents published as part of the Ecological Services Manual of the USFWS (USFWS 1980). One of these documents, entitled "Habitat as a Basis for Environmental Assessment" (101 ESM), addresses the rationale for a habitat-based technique and discusses the conceptual approach to habitat assessment.

The Habitat Evaluation Procedures (102 ESM) describes how the concepts of habitat evaluation can be implemented in a standardized procedure for conducting impact assessments.

Another document, "Standards for the Development of Habitat Suitability Index Models for Use with the Habitat Evaluation Procedures" (103 ESM), provides guidance in the development of habitat models. These documents provide the user with a basic tool for habitat evaluations.

Table of Contents

Table of Contents --Cont.

1. Introduction

Natural resource management as we know it today is the result of a long evolutionary process influenced by changing public attitudes and legal mandates. The early history of this country portrayed an attitude of natural resource exploitation, with little regard for damages to the environment or losses to future generations of Americans. Fortunately, these attitudes toward natural resources in general, and to fish and wildlife in particular, have changed (Udall 1963; Trefethen 1975). Legislative actions have resulted from these changes, and in some instances, have been initiators of change (Bean 1978).

The purpose of this document is to describe the concepts behind, and the rationale in support of, a habitat-based impact assessment methodology currently available for use in certain aspects of fish and wildlife resource management. The document does not, however, conclude that habitat is the only basis for environmental assessments. Several assessment methods are discussed and compared to selected criteria in reaching the conclusion that a habitat approach is most appropriate within the current legal and institutional constraints on the USFWS. Other criteria can be used, and other equally valid arguments can be made in support of other approaches for impact assessment. This document does not specifically address non-habitat-based impact assessment methodologies such as the monetary and user-day approaches.

This document presents deductive reasoning in support of a habitat approach to impact assessment. It begins with a discussion of the legal mandates for impact assessments (101 ESM 2), progresses through a description of the ecological basis for impact assessments (101 ESM 3 and 4), and concludes (101 ESM 5) with the identification of an assessment technique which has evolved within the USFWS under the selective pressures of legal mandates and accepted ecological principles.

2. Legal Basis for Environmental Impact Assessments

This chapter identifies and describes the legal mandates for environmental impact assessment by reviewing recent Federal legislation affecting fish and wildlife resources. For a compilation of relevant Federal legislations enacted before those treated in this chapter, the reader is referred to Bean (1977) and Congressional Research Service, Library of Congress (1977).

2.1 The evolution of environmental policy. Convergence of natural resource conservation legislation and regulatory mandates to protect public health and welfare first became apparent in the late 1950's and 1960's. The conservation ethic, developed in the early part of the 20th century, evolved into a more holistic environmental perspective which recognized the interdependence of man and his environment. Environmental quality became an important attribute of the public welfare. Early Federal legislation, known as the Wildlife Coordination Act of 1934, later to become the Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661, *et seq*.), authorized the assessment of adverse environmental impacts associated with Federal water projects. Public concern for the protection of environmental quality, previously applied principally to Federal construction projects, was given application throughout all Federal agencies by the passage of the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321, *et seq*.). NEPA is the culmination of national concern in the 1960's for natural resource conservation, and public health and welfare legislation. NEPA set the tenor and policy basis for succeeding Federal and State environmental legislation, and established the Council on Environmental Quality.

2.2 Legal mandates for environmental impact assessments. NEPA is the landmark of environmental legislation and has served as the policy umbrella and mandate for numerous other Federal legislation. NEPA sets forth as its purposes: "To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation...." In passing NEPA, Congress recognized the dependence and inseparability of the public health and welfare of the Nation and environmental quality. NEPA applies to all the activities and programs of all Federal agencies. Furthermore, it requires all agencies to consider environmental values along with economic or developmental considerations. Regarding assessment activities, NEPA further stated that all Federal agencies shall:

> "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment," and

2. Legal Basis for Environmental Impact Assessments

2.3 Variability in focus of environmental impact assessments. A common feature of all of the laws listed above is the necessity to inventory and quantify the status of air, water, land, and other ecological resources in order to assess, predict, or regulate resource changes resulting from various types of man-induced impacts. A comprehensive definition of environmental impact assessment has been suggested by the International Council of Scientific Unions (1975) as: "an activity designed to identify and predict the impact on man's health and well-being, of legislative proposals, policies, programs, projects, and operational procedures, and to interpret and communicate information about the impacts."

Unfortunately, many differences exist in the focus, scope, and resolution of environmental impact assessments. This stems largely from ambiguous and occasionally contradictory language of various Federal Acts and the lack of concensus among scientists working in this field. The problem is particularly pronounced in assessments dealing with ecological or wildlife impacts. This has contributed significantly to the variability of information gathered by agencies charged by statute with conducting impact assessments.

Congressional requirements to assess impacts on fish and wildlife resources are generally framed around four indicators of public interest: species-populations, biological integrity, environmental values, and habitat. The four indicators are identified in the language of some key environmental legislation. References to wildlife resources in legislative acts are often intentionally vague to allow for more definitive clarification in the regulations drafted by the implementing agency. Frequently, wildlife resources are not mentioned specifically, but are lumped under the general term "environmental resource values."

A. Species-population. The concept that fish and wildlife species or populations or other descriptors thereof can be the basis for determining and assessing impacts is most clearly illustrated in the language of the Clean Water Act. Section 304(a)(1)(A) "Information and Guidelines" states that criteria for water quality should include "extent of all identifiable effects on health and welfare including ...plankton, fish, shellfish, wildlife, plant life..." Section 316(a) requires applicants for a variance from thermal discharge guidelines to "assure the protection and propagation of a balanced, indigenous population of fish, shellfish, and wildlife...." This language reflects the interim goal of the Act under Section 101(a)(2) of achieving water quality "which provides for the protection and propagation of fish, shellfish, and wildlife...." Several other Acts could be interpreted as requiring a species-population approach, notably the Endangered Species Act, the Federal Nonnuclear Energy Research and Development Act, and the Surface Mining Control and Reclamation Act.

2. Legal Basis for Environmental Impact Assessments

2) The environmental impact assessment should objectively predict the quantitative and qualitative short and long term changes in physical, chemical, and biological features associated with alternative ways of achieving the proposed objective. The "goodness" or "badness" of each alternative is determined by the decisionmaker(s) and is not made a part of the assessment.

None of the environmental laws or regulations which require impact assessment prescribe a methodology to be used in the collection, compilation, analysis, or evaluation of natural resource information. The focus of subsequent chapters will be to describe the concepts behind, and the rationale in support of, a habitat-based impact assessment methodology currently available for use in certain aspects of fish and wildlife resource management.

"identify and develop methods and procedures, in consultation with the Council on Environmental Quality..., which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations."

Some of the more prominent legislative acts which mandate Federal agencies to environmental conservation include:

A. Archeological and Historic Preservation Act, 16 U.S.C. 469, et seq.
B. Clear Air Act, as amended, 42 U.S.C. 7401, et seq.
C. Clear Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.
D. Coastal Zone Management Act, 16 U.S.C. 1451, et seq.
E. Endangered Species Act, 16 U.S.C. 1531, et seq.
F. Estuary Protection Act, 16 U.S.C. 1221, et seq.
G. Federal Land Policy and Management Act, 43 U.S.C. 1701, et seq.
H. Federal Nonnuclear Energy Research and Development Act, 42 U.S.C. 5901 et seq.
I. Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), et seq.
J. Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.
K. Forest and Rangeland Renewable Resources Planning Act, 16 U.S.C. 1601, et seq.
L. Land and Water Conservation Fund Act, 16 U.S.C. 4601 - 4601-11, et seq.
M. Marine Protection, Research and Sanctuary Act, 33 U.S.C. 1401, et seq.
N. National Environmental Policy Act, 42 U.S.C. 4321, et seq.
O. National Historic Preservation Act, 16 U.S.C. 470a, et seq.
P. National Forest Management Act, 16 U.S.C. 472, et seq.
Q. Rivers and Harbors Act, 33 U.S.C. 403, et seq.
R. Soil and Water Resources Conservation Act, 16 U.S.C. 2001, et seq.
S. Surface Mining Control and Reclamation Act, 30 U.S.C. 1201, et seq.
T. Water Resources Planning Act, 42 U.S.C. 1962, et seq.
U. Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.
V. Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.

These Acts address the protection, inventory, conservation, or rehabilitation of the environmental resources of the Nation. Many of the above statutes represent organic legislation of Federal agencies such as the Water Resources Council, the Bureau of Land Management, and the Office of Surface Mining Reclamation and Enforcement.

B. Biological integrity. Interestingly, the Clean Water Act also is associated with the biological or ecological integrity approach which attempts to evaluate impacts from an integrated ecosystem viewpoint. The goal of that Act [Section 101(a)] states "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The ecological basis of this concept is further reflected in Section 304(a)(1)(C) which calls for water quality criteria based "on the effects of pollutants on biological community diversity, productivity, stability..." The Council on Environmental Quality regulations implementing NEPA defines the "effects" which are to be addressed in impact assessments (43 C.F.R. 1508.8): "Effects include ecological (such as effects on natural resources and on the components, structure, and functioning of affected ecosystems)...."

C. Environmental values. The equal consideration of environmental values and economic values to be derived or foregone from a given project or development activity is the essence of the "equal dignity" concept mandated by NEPA. The equal consideration or "values" approach to environmental impact assessment is best illustrated by the Water Resources Council's Principles and Standards (P&S) (38 F.R. 24778, 44 F.R. Part X, and 18 C.F.R. 713). The P&S establish procedures designed to measure and quantify the beneficial and adverse effect of water and land developments on two objectives: national economic development and environmental quality. P&S Section II (B) indicates that: "Beneficial and adverse effects are measured in monetary or nonmonetary terms." P&S establishes the approach to impact assessment based on estimating the monetary and nonmonetary "value" of the components of environmental quality. For example, such things as "biological resources," "ecological systems," "natural beauty," "historical resources," and "water and air quality," are to be compared with economic development factors such as power generation, employment, and flood control. Although philosophically admirable, the implementation of the values approach has been hampered by the difficulty of placing values on intangible and intrinsic environmental components which have unknown or nondeterminable market value.

D. Habitat. The fourth approach to environmental impact assessment is habitat analysis. The Federal Land Policy and Management Act declared that the policy of Congress with regard to the management of public lands under Section 102(a)(8) includes the provision of "food and habitat for fish and wildlife and domestic animals." Section 201(a) of the Act requires "an inventory of all public lands and their resource and other values... giving priority to areas of critical environmental concern." Areas of "critical environmental concern" are defined in Section 103 to include "important fish and wildlife resources."

2. Legal Basis for Environmental Impact Assessments

The Fish and Wildlife Coordination Act requires the USFWS, in cooperation with State fish and wildlife agencies, to conduct surveys and investigations for the conservation of fish and wildlife resources. This Act pertains to Federal construction projects or federally-permitted or licensed projects affecting any stream or other body of water. The Act does not specify any particular assessment methodology. However, the USFWS's draft regulations (F.R. Vol. 44. No. 98. May 18, 1979) implementing this Act recognize the concept and specify the use of habitat values.

The Forest and Rangeland Renewable Resources Planning Act also directs the Department of Agriculture to conduct renewable resource assessments. "The evaluation shall assess the balance between economic factors and environmental quality factors. Program benefits shall include, but not be limited to, environmental quality factors, such as esthetic, public access, wildlife habitat, recreational ..." (16 U.S.C. 1606(d)). Similarly, the Soil and Water Resources Conservation Act calls for "appraisals" including, under Section 5(a)(1), "data on quality and quantity of soil, water, and related resources including fish and wildlife habitats."

The Endangered Species Act also recognizes the importance of habitat to the protection, preservation, and restoration of endangered and threatened species. Section 3(5)(A) defines the term "critical habitat" and Section 4(a)(1) empowers the Secretary of the Interior to "specify any habitat of such species which is then considered to be critical habitat." Section 7(a)(2) requires each Federal agency to ensure that its activities do not "result in the destruction or adverse modification of habitat of such species...." Section 7(b) and 7(c) provide for "biological assessments" and "biological opinions" to make such determinations.

Recent rules and regulations pursuant to the Surface Mining Control and Reclamation Act require the assessment of impacts to fish and wildlife resources. Section 779.20(a) of the Office of Surface Mining Reclamation and Enforcement (OSM) Regulations in 30 C.F.R. requires mining permit applicants to include "a study of fish and wildlife and their habitats." Introductory material to Section 779.20 (March 13, 1979 Federal Register publication, 44 F.R. 15037) of the OSM regulations indicates that the agency's interpretation of Section 515(b)(24) ("minimize disturbance and adverse impacts of the operation on fish, wildlife, and related environmental values..."), is that it includes habitat.

2.4 Variability in scope and resolution of environmental impact assessments. A fairly broad spectrum exists in Federal laws and policies with regard to the resolution and geographic scope of assessments, ranging from broad-based national assessments to site-specific plans. For example,

2. Legal Basis for Environmental Impact Assessments

Federal agencies' legislation addressing impact assessment as part of a regulatory or consultation function tend to require a high degree of resolution and site specificity (e.g., a mining site plan, a stream reach, a construction project site, a timber sale, or a grazing management unit). The Surface Mining Control and Reclamation Act and the Clean Water Act exemplify this category of resolution.

A second category involves legislation calling for basinwide or regional planning assessments with an associated lower degree of resolution. Examples of this type of assessment would include Water Resources Council 13A assessments, Federal Nonnuclear Energy Research and Development Act, P&S level A and B studies, and most NEPA Environmental Impact Statements (EIS's).

The third category or level of resolution includes impact assessments on a national or major geographic basis such as programmatic EIS's, national assessments, and inventories designed to tabulate the natural resources of "all public lands" or "all National forest and rangelands".

2.5 Elements common to all environmental impact assessments. The foregoing discussion pointed out that the legal mandates for environmental impact assessments vary in approach, scope, and resolution. However, at least two common points are recognized:

1) Interactions between physical, chemical, and biological components dictate environmental quality. Thus, to varying degrees, an ecosystem approach to impact assessments is defined.

2) Man has the capability of exploiting natural resources to a point at which his life support system may begin to break down. The legislation subsequent to NEPA provides recognition and reaffirmation of the NEPA goals that modern industrialized society must provide in law for the maintenance, conservation, or rehabilitation of the basic life support system, both for existing and for future generations.

Therefore it follows that certain elements should be common to all potential environmental impact assessment methods. These are:

1) The environmental impact assessment methodology should have the capability to quantify the extent and status of various natural resource components and their susceptibility to irreparable damage or loss. All chemical, physical, biological, economic, and social parameters that are relevant to the change expected to result from a proposed action, should be addressed.

3. Ecological Basis for Environmental Impact Assessments

The preceding chapter explored the legal basis for impact assessments and concluded that there are no clearly defined legal directives for the use of particular methodologies. The purpose of this chapter is to review the ecological basis for environmental impact assessments, and then to explore the general utility of various approaches that might be used to assess impacts on fish and wildlife resources.

3.1 The ecosystem as an organizational unit. Environment has been defined as "the sum total of all physical and biological factors impinging upon a particular organismic unit" (Pianka 1974:2). The "organismic unit" of interest may be an individual, a population of individuals, or a community of populations. The task of assessing impacts on the environment involves: (1) identifying the biological unit whose environment is to be assessed; (2) identifying the factors impinging upon the defined unit(s); and (3) determining how the proposed action will impact the defined unit(s) through alteration of the physical and biological factors impinging on it.

This three step approach which treats factors affecting individuals, populations, and communities is founded on the organizational concept of an ecosystem. An ecosystem approach to environmental assessment may be both natural and artificial. Treating organisms and their environments as functional units is a natural means of organizing efforts in impact assessment. However, artificiality may enter the process when attempts are made to operationally define ecosystems or to delineate actual ecosystem boundaries. Ecosystems can be of any physical size if they are defined by functional attributes (McNaughton and Wolf 1973). However, it should be recognized that setting spatial limits becomes arbitrary because ecosystems represent a continuance in time and space both operationally and conceptually (Johnson 1977).

Unfortunately, ecosystems are seldom treated as a functional continuant during impact assessment; instead the responsibilities and interests of most resource agencies lie with particular ecosystem components. For example, the U.S. Fish and Wildlife Service is specifically charged with the protection of fish and wildlife resources. Fish and wildlife resources are dependent on, and functionally related to, other ecosystem components. In this example, the ecosystem approach is valid as long as the interactions between fish and wildlife and other ecosystem components are defined and considered during an impact assessment. In many instances this integration does not occur and the impact assessment is nothing more than a brief summary of information.

3.2 Methods for assessing fish and wildlife components of ecosystems. Impact assessment requires documentation of the quantity and quality of existing resources, and prediction of how these resources will change in the

future both naturally, and as a result of man's actions. The choice of an assessment methodology should be governed by how well the technique meets certain criteria related to application and implementation of the assessment process. Some potential criteria include:

(1) The assessment method should document and display data in a manner which allows decisionmakers to compare present conditions with future options and alternatives.

(2) The assessment method should have predictive capabilities amenable to documenting changes in quantity and quality of fish and wildlife resources over time. It is not enough to document existing resources; the assessment method must be able to project changes in the resource base which would occur naturally or as a result of implementation of a proposed action by man.

(3) The assessment method must be practical to implement. Data availability, time, and monetary constraints must be considered in the practical application of any method.

(4) The assessment method must be sensitive enough to identify differing types and magnitudes of impacts ranging from enhancement, to no impact, some loss, or to total loss of the resource.

(5) The assessment method should generate data with biological validity, but in units readily understood by both the public and decisionmakers. These data should be amenable to integration with data from other disciplines, such as socioeconomic analyses.

(6) The assessment method should be complete and self-contained yet capable of being improved through the incorporation of new knowledge and techniques as the state-of-the-knowledge advances.

There are probably other criteria which would be applicable, but those presented represent the minimum which should be considered when selecting an assessment method. The following discussion addresses some potential assessment methods in light of how they either meet or fail to meet these criteria.

A. Assessment through analysis of energy flow. One of the most fundamental approaches to evaluation of ecosystems is through analysis of how energy flows through the system and how it is used by various components. Almost any proposed action by man can be summarized as impacting the ecosystem by alteration of energy flow through the system. An energy flow approach has been used as an effective analytic tool in various small and physically well defined systems

(Kormondy 1969; Odum 1971). Some inland aquatic ecosystems lend themselves to this approach (Odum 1957). Each trophic level, from primary producers such as plankton through various levels of consumers, exhibit fairly efficient and measurable energy transfers. However, available energy entering the system does not necessarily determine production of a given species or even a trophic level in terrestrial systems (Wagner 1969). A great deal of energy (nutrient pool) is "locked up" in inaccessible or inedible plant parts and therefore is unavailable to other ecosystem components for extended periods. Energy flow in ecosystems is perhaps more difficult to measure in practice than are aspects of the nutrients involved in its transfer. Biochemical cycle parameters such as transfer rates and pool size are costly to measure, and the interpretation of these data in an impact assessment context is difficult (Johnson 1977).

Systems analysis, systems simulation, and other promising tools have improved the ecologist's capabilities to measure and analyze energy flow in large systems on an experimental basis, but the resulting large scale models still only infrequently produce reliable predictions (Odum 1977). The use of such models also often requires data that are costly and time consuming to collect, and sometimes impractical to measure for each assessment activity.

B. Assessment through population estimation. Of practical value to the resource manager are methods of assessment which not only provide measures of impacts, but which also provide information on population size and production of species of public concern. Many EIS readers are concerned with how many animals will be lost due to the proposed action (Giles 1974). Therefore, methods which document future changes in supply of fish and wildlife resources available for both consumptive and nonconsumptive uses by man should be considered in the assessment process.

The ultimate quantification of changes in numbers of individuals (supply) would be derived from analyses of how various chemical, physical and biological parameters of the ecosystem interact to influence the energy balance of individual animals and, thus their probability of survival and contribution to future populations. However, for the fish and wildlife manager, often the only practical approach to assessment involves either direct or indirect methods of population estimation.

(1) Population estimation - direct approach. Direct population estimation usually involves some type of census which, by definition, implies a complete count of individuals within a

specific area (Overton and Davis 1969); however, virtually all real world situations must rely on estimation techniques. Direct estimation techniques are applicable to populations of individuals which are relatively sedentary (e.g., territorial males of many passerine species), or are concentrated on limited areas (e.g., wintering waterfowl or fish migrating through a fish ladder). However, many species do not lend themselves to accurate, direct population estimation because of mobility, secretive behavior, or habitat characteristics which make observation or counts difficult. Indirect estimation techniques must be used for these types of populations (Watt 1968).

(2) Population estimation - indirect approach. Most indirect methods of population estimation involve the use of indices. Two types of indices are commonly used to indirectly estimate population size. The first type involves a count (e.g., time-area count) taken in a manner which does not permit population estimation unless sampling probabilities are estimated. The second type of index is based on counts of some parameter (e.g., pellet group counts) associated with the species of interest. The strengths and weaknesses of both techniques have been discussed by Overton and Davis (1969).

Estimation of animal numbers at any one point in time is difficult whether direct or indirect methods are used. Several methods should be used (Watt 1968) to ensure accuracy, but this increases the costs of obtaining estimates. Most uses of population size estimates also include a spatial dimension (e.g., density = number of animals per unit area) which requires an estimate of the space utilized by the population under consideration (Krebs 1972).

Even the simplest population estimation model requires data from both the breeding population and their offspring for several consecutive years. Correlative models which reflect past population history are of limited predictive value (Watt 1968). Mechanistic models based on a biological understanding of the species are technically attractive, but the amount of data required to produce such a documented, predictive model is prohibitive for most ecological assessment purposes (Krebs 1972).

Population estimates alone are considered by many to be unreliable indicators of habitat value. Sampling errors, cyclic fluctuations of populations, and the lack of time series

data, all contribute to the problem. Thus, where changes in supply of selected fish and wildlife populations may be a quantity to which decisionmakers and the public easily relate, estimates of changes in numbers of individuals may be difficult and costly to obtain, and too time consuming to use for many impact assessments.

C. Assessment through habitat quality. Habitat has been defined to incorporate several interrelated concepts dealing with space, time, and function (Coulombe 1977). Basically, however, habitat is the place occupied by a specific population within a community of populations (Smith 1974), and often can be characterized by a dominant plant form or some physical characteristic (Ricklefs 1973). Each species requires a particular habitat to supply the space, food, cover, and other requirements for survival. Thus, species are the products of their habitats.

Much of the variability observed in numbers of species and numbers of individuals within populations results from differences in availability of food, cover, water, and other requirements, and in the structural characteristics of the habitat itself (Black and Thomas 1978). Different qualities of habitats produce different densities of various populations. Attempts to quantify habitat quality often involve the use of indices, applied at the individual, population, or community levels.

Some of the most frequently used types of indices are the so-called "condition indices" which involve measurements of some particular characteristic of an animal (e.g., bone marrow fat) to subsequently evaluate the condition of both the animal and its habitat (Giles 1978). Condition indices, like some forms of population indices, are most useful when taken over many years and then compared to some standard to obtain trend information. Such indices are of limited utility for prediction of impacts resulting from specific proposed actions which would alter factors interacting to yield the original index.

Various forms of diversity indices often are used to characterize habitats in an attempt to obtain some measure of quality (Asherin et al. 1979). One of the most common is the bird species diversity index used by avian ecologists. Such indices account for both numbers of species and numbers of individuals of each species present in a particular habitat (Balda 1975). However, diversity indices are insensitive to which species are present (Wiens 1978), often require detailed and expensive measurements which preclude their practical application by resource managers (Thomas et al. 1978), and

suffer from the same problems as all biological indices, namely, identification of the standard of comparison (Inhaber 1976). The methods of determination and ecological relevance of the diversity index has been seriously questioned (Hurlbert 1971); the plasticity of species and species groups in ecosystem structure makes the interpretation of diversity index data difficult (Johnson 1977).

3.3 A unifying approach. Each of the potential approaches to impact assessment described above (energy flow, populations estimation, and habitat quality) differ in their ability to meet previously identified criteria (101 ESM 3.2). Analysis of energy flow may be the most scientifically sound method, but is not practical at present because of time and monetary constraints which accompany most impact assessments. Both the population and habitat approaches meet the criteria with the following basic differences:

(1) Population approaches result in analyses with actual dimensions (e.g., number of animals per unit area).

(2) Habitat approaches may be somewhat easier to implement when considering typical time and monetary constraints.

What is needed in impact assessment is a unifying concept which integrates features common to both the concepts of habitat with its relative ease of implementation and population with its explicit units of measure, or "a land parameter measured in animal units" (Giles 1978:194).

Understanding the relationships between habitat and animals requires that both the supply of habitat resources available and the life requirements of the species be known (Moen 1973). The supply of resources available to a particular animal can be determined from various characteristics of the habitat after the animal's requirements are known. For the better studied species these basic requirements, e.g., food, water, cover, and others, are reasonably well known. The unifying concept between habitat quality (i.e., the ability of a habitat to supply life requirements) and numbers of animals a habitat can support is carrying capacity.

4. Carrying Capacity and Habitat as a Basis for Impact Assessments

The concept of carrying capacity integrates the habitat and population themes in a time dimension and, in doing so, provides a potential basis for impact assessments. The purposes of this chapter are to define and discuss the estimation of carrying capcity, and then evaluate the utility of incorporating the concepts presented in this document into a practical method for assessing the impacts of man's actions on fish and wildlife resources.

4.1 Definition of carrying capacity. Strictly speaking, carrying capacity is a population concept with the underlying theme of numbers of animals supported by some unit of area. In population ecology terms, it is "the density of organisms (i.e., the number per unit area) at which the net reproductive rate (R_0) equals unity and the intrinsic rate of increase (r) is zero" (Pianka 1974:82). Pianka goes on to explain that carrying capacity is "an extremely complicated and confounded quantity, for it necessarily includes both renewable and nonrenewable resources, as well as limiting effects of predators and competitors, all of which are variables themselves." Carrying capacity is the "K" in various versions of the Verhulst-Pearl logistic population-growth equation. Defined in this context, carrying capacity is the population density at an upper asymptotic level of population growth. After a population reaches this level it may fluctuate around K due to chance events. The asymptotic density is maintained by density-dependent environmental factors.

Wildlife resource managers often are more liberal in their perceptions of carrying capacity than are population ecologists and may use the term in a variety of contexts (Edwards and Fowle 1955). When confusion occurs, it can be traced to a lack of user definition and not to the integrating role of this useful concept. Giles (1978) has recently attempted to alleviate confusion by suggesting that carrying capacity be defined for a population with a user-specified quality of biomass (e.g., specified sex and age ratios). With this approach, carrying capacity is the quantity of the specified population for which a particular area will supply all energetic and physiological requirements over a long, but defined, period of time.

4.2 Estimation of carrying capacity. Carrying capacity (K in the Verhulst-Pearl logistic population growth equation) may be estimated empirically with regression techniques described by Watt (1968) and Poole (1974). These regression techniques require that population densities be recorded for various stages of population growth. The technique is based on observed population densities, thus it does not provide the ability to predict future changes in carrying capacity. For that latter reason, and others discussed in 101 ESM 3, population estimation is not a viable technique for impact assessment purposes.

Another technique for estimating carrying capacity is the traditional resource inventory. With this technique, carrying capacity is estimated

based on how well the habitat will meet the known physiological and behavioral needs of a species. Ecologists working with ungulates have historically based carrying capacity estimates on caloric and nutritional values of foods provided by the habitat. Examples of the data and calculations required are described by Moen (1973) and Mautz (1978). Others, including avian ecologists, have considered structural aspects of the habitat as important determinants of carrying capacity (Elton and Miller 1953). Carrying capacity estimates based on the resource inventory approach will nearly always be estimates of "potential," because the limiting effects of other species (competitors and predators) are difficult to explicitly include in the calculations.

4.3 Application of habitat concepts to impact assessments. Structural and physical features of habitat are measurable and because vegetational succession is predictable to a certain extent, future habitat values can be projected with some confidence. However, numbers of individuals fluctuate naturally over time and often independently of structural and physical features of available habitat. These fluctuations can be difficult to measure or predict and are often caused by epizootic diseases, excessive departures from normal weather patterns, or other stochastic events not directly related to habitat. More common however, are the effects of predation and competition on numbers of individuals utilizing a particular habitat (Wagner 1969; Partridge 1978). For example, predator-prey studies by Rogers et al. (1980) indicated that, in similar habitat, white-tailed deer densities were higher in the buffer zones between wolf pack territories than in the center of individual territories.

In regard to competition, avian ecologists are making rapid advances in deciphering the influence of competition on animal numbers. For example, a recent study (Williams and Batzli 1979a,b) indicated that the presence or absence of one particular species within a guild of bark foraging birds affected whether or not other guild members would use a particular habitat segment, how they would use it, and in what numbers. The implications of these studies and others are directly applicable to the objectives of impact assessment. Numbers of species and numbers of individuals often may change for unpredictable reasons, but habitat potential remains unchanged. Because of its relative stability, it is this habitat potential which should be documented by the wildlife manager interested in ecologically valid impact assessment.

Two factors support impact assessments based on habitat potential. First, the time scale for predictions can come close to matching the time span over which impacts will occur. For many impact studies performed by the USFWS involving long-term modifications of land use, the most useful information for decisionmaking is the long-term trend in fish and wildlife

resources. Predicted short-term (e.g., seasonal or annual) fluctuations in populations may have little influence on a land use decision. Secondly, the degree to which a predicted impact is considered significant is partially a function of socioeconomic preferences for the species involved. When recommendations for land use decisions are based on habitat potential it is possible to maximize the number of future management options, recognizing possible future changes in socioeconomic preferences.

4.4 Limitations of the habitat approach. The habitat approach, like any approach used for impact assessments, has limitations which define the limits of application and identify potential problem areas where good professional judgement is required. Performing impact assessments with a habitat approach, as described herein, basically limits application of the methodology to those situations in which measurable and predictable habitat changes are an important variable. Many impact studies (e.g., harvest management and predator control) cannot be adequately performed solely with a habitat approach but require other analytical capabilities.

The habitat approach presents a relatively static view of the ecosystem and forces a long-term "averaging" type of analysis. Although this is described as a positive attribute in earlier sections of this document, there is no assurance that wildlife populations will exist at the potential levels predicted by habitat analyses. A habitat approach may not include all of the many environmental or behavioral variables that often limit populations below the habitat potential. Moreover, socioeconomic or political constraints imposed by man may prevent the actual growth of certain species populations to their potential levels.

5. A Habitat-Based Impact Assessment Technique

The USFWS (1980) has developed a procedure for documenting predicted impacts to fish and wildlife from proposed land and water resource development projects. The procedure is based on the concepts of habitat potential discussed in 101 ESM 4. The purpose of this concluding chapter is to briefly discuss the procedure and identify its strengths and limitations when used in the impact assessment process.

5.1 The Habitat Evaluation Procedures. The Habitat Evaluation Procedures (HEP) have been developed (USFWS 1980) in response to the need to document the nonmonetary value of fish and wildlife resources. HEP evolved from an assessment method developed in Missouri (Daniels and Lamaire 1974) and is based on the fundamental assumption that habitat quality and quantity can be numerically described. Numerical description permits options and alternatives to be compared when numerical changes are the essence of impact assessment.

HEP is a species-habitat approach to impact assessment, and habitat quality for selected evaluation species is documented with an index, the Habitat Suitability Index (HSI). This value is derived from an evaluation of the ability of key habitat components to supply the life requisites of selected species of fish and wildlife. Evaluation involves using the same key habitat components to compare existing habitat conditions and optimum habitat conditions for the species of interest. Optimum conditions are those associated with the highest potential densities of the species within a defined area. The HSI value obtained from this comparison thus becomes an index to carrying capacity for that species.

The index ranges from 0.0 to 1.0, and for operational purposes in HEP, each increment of change must be identical to any other. For example, a change in HSI from 0.1 to 0.2 must represent the same magnitude of change as a change from 0.2 to 0.3, and so forth. Therefore, HSI must be linearly related to carrying capacity. This is an operational restriction imposed by the use of HSI in HEP. However, it is a restriction easily complied with; if the relationship between HSI and carrying capacity is unknown, it is assumed to be linear. If the relationship is nonlinear, it is converted to a linear function.

HEP attempts to incorporate concepts from both the population and habitat theories by evaluating habitat quality for specific species. Prior to the 1980 edition of HEP, this was done subjectively based on the professional judgement of a team of biologists. The habitat quality values were multiplied by area and aggregated to obtain a "habitat" score. In the 1980 edition of HEP, HSI values are obtained for

individual species through use of documented habitat suitability models employing measurable key habitat variables (e.g., percent canopy closure). The HSI values are multiplied by area of available habitat to obtain Habitat Units (HU's) for individual species. These values are used in the HEP system for comparative purposes. No aggregation of species' HSI (or HU's) occurs.

Many potential users tend to consider the HSI value as synonymous with the entire HEP system. This is not the case. HEP can be compared to a bookkeeping ledger; both passively display, and thereby document, values obtained from other sources. HEP is a data management system; it is the data it manages, i.e., the index of quality and the quantity of available habitat, which are of interest in impact assessment.

5.2 Attributes and limitations of the Habitat Evaluation Procedures. As with other approaches, HEP differs in its ability to meet the previously identified evaluation criteria (101 ESM 3.2) for an impact assessment methodology:

(1) Various forms are used in HEP to display and document HSI, area, and HU's for each evaluation species. Comparisons can be made either between two areas at one point in time, or for one area for several points in time, for any proposed action. However, the ability to document data and ultimately compare alternatives is not unique to the HEP system.

(2) The differences in quality (HSI) and quantity (area) between existing habitat conditions (baseline) and various projected future sets of conditions document project-related impacts to selected evaluation species. HEP currently does not provide guidance for performing future projections. Therefore, projected impacts are no better than the user's ability to predict future conditions.

(3) HEP can be applied at any level of assessment. However, data requirements and costs increase as more species are considered and their respective habitat models become more complex. HSI models not only provide an index value of quality, but also document which habitat variables were considered and their respective values. The level of detail for such "models" must fit the user's objectives for impact assessment.

(4) The identification of differing types and magnitudes of impacts is dependent on the validity and sensitivity of the HSI models used to generate data for HEP. As with other approaches, the results of an impact assessment employing HEP are no better than the reliability of resource data used.

5. A Habitat-Based Impact Assessment Technique

5) HU's serve not only as the principal units of comparison in HEP, but also as a standard vehicle of communication, integrating both quality and quantity of habitat. Changes in HU's represent potential impacts from proposed actions. Such changes are annualized in order to be comparable with the action agencies' benefit/cost analyses. Applications of annualized HU's include impact assessments, compensation studies, and human use analyses. In such analyses, one HU lost for a species must be directly comparable to one HU gained for that species. The latter association explains the requirement for a linear relationship between HSI and carrying capacity.

6) HEP is a species-habitat-based assessment methodology. It is applicable only for the species evaluated and does not directly relate that species with other ecosystem components. HEP conceptually addresses only the issues of species populations and habitat, among the four indicators of public interest identified in 101 ESM 2.3. However, the degree to which these indicators are addressed by HEP is dictated by the HSI models. Through improved HSI models, it may be possible to more completely treat the remaining issues of biological integrity and environmental values.

In summary, the HU data developed are the essence of the HEP methodology. The identified changes in habitat quality and quantity provide the basis for biologists to compare alternatives for the evaluation species selected. HEP is a convenient means of documenting and displaying, in standard units, the predicted effects of proposed actions. It is a tool available to resource managers who must make knowledgeable decisions. For further information, the reader should consult the "Habitat Evaluation Procedures" (102 ESM) and "Standards for the Development of Habitat Suitability Index Models for Use with the Habitat Evaluation Procedures" (103 ESM).

6. References Cited

Asherin, D. A., H. L. Short, and J. E. Roelle. 1979. Regional evaluation of wildlife habitat quality using rapid assessment methodologies. Trans. N. Am. Wildl. Nat. Resour. Conf. 44:404-424.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. pp. 59-80 In D. R. Smith (Tech. Coord.). Proceedings of the symposium on management of forest and range habitats for nongame birds. U.S.D.A. For. Serv. Gen. Tech. Rep. WO-1. Tuscson, Arizona. 343 pp.

Bean, M. J. 1977. The evolution of national wildlife law. Council on Environmental Quality. Washington, D.C. 485 pp.

Bean, M. J. 1978. Federal wildlife law. pp. 279-289 In H. P. Brokaw (Ed.). Wildlife and America. Council on Environmental Quality. Washington, D.C. 532 pp.

Black, H., Jr., and J. W. Thomas. 1978. Forest and range wildlife habitat management: ecological principles and management systems. pp. 47-55 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Congressional Research Service. The Library of Congress. 1977. A compilation of Federal laws relating to conservation and development of our Nation's fish and wildlife resources, environmental quality, and oceanography. Serial No. 95-B. Printed for the Committee on Merchant Marine and Fisheries. U.S. House of Representatives. Washington, D.C. 933 pp.

Coulombe, H. N. 1977. Summary remarks. pp. 593-604 In A. Marmelstein (General Chairman). Classification, inventory, and analysis of fish and wildlife habitat: the proceedings of a National symposium. FWS/OBS-78/76. Washington, D.C. 604 pp.

Daniels, C., and R. Lamaire. 1974. Evaluating effects of water resource developments on wildlife habitat. Wildl. Soc. Bull. 2(3):114-118.

Edwards, R. Y., and C. D. Fowle. 1955. The concept of carrying capacity. Trans. N. Am. Wildl. Conf. 20:589-602.

Elton, C. S., and R. S. Miller. 1953. The ecological survey of animal communities: with a practical system of classifying habitats by structural characters. J. Ecology 42:460-496.

6. References Cited

Giles, R. H., Jr. 1974. Forest-wildlife components of environmental impact statements. pp. 120-126 In J. P. Slusher and T. M. Hinckly (Eds.). Timber-wildlife management symposium. Missouri Academy of Science Occasional Paper 3. Columbia, Missouri. 131 pp.

Giles, R. H., Jr. 1978. Wildlife management. W. H. Freeman and Company. San Francisco, California. 416 pp.

Hurlbert, S. H. 1971. The non-concept of species diversity: a critique and alternative parameters. Ecology 52(4):577-586.

Inhaber, H. 1976. Environmental indices. John Wiley and Sons. New York, New York. 178 pp.

International Council of Scientific Unions. 1975. Environmental impact assessment: principles and procedures. SCOPE Workshop on Impact Studies in the Environments (WISE). United Nations Environmental Program (UNEP), Environmental Canada and UNESCO SCOPE Report 5, Toronto, Canada.

Johnson, P. L. (Ed.). 1977. An ecosystem paradigm for ecology. Oak Ridge Associated Universities, Oak Ridge, Tennessee. ORAU-129. 20 pp.

Kormondy, E. J. 1969. Concepts of ecology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 209 pp.

Krebs, C. J. 1972. Ecology: the experimental analysis of distribution and abundance. Harper and Row Publishers, New York, New York. 694 pp.

Mautz, W. W. 1978. Nutrition and carrying capacity. pp. 321-348 In J. L. Schmidt and D. L. Gilbert (Eds.). Big game of North America. The Wildlife Management Institute and Stackpole Books, Washington, D.C. and Harrisburg, Pennsylvania. 494 pp.

McNaughton, S. J., and L. L. Wolf. 1973. General ecology. Holt, Rinehart and Winston, Inc. New York, New York. 710 pp.

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Company. San Francisco, California. 458 pp.

Odum, E. P. 1971. Fundamentals of ecology. W. B. Saunders Company. Philadelphia, Pennsylvania. 574 pp.

Odum, E. P. 1977. The emergence of ecology as a new integrative discipline. Science 195(4284):1289-1293.

Odum, H. T. 1957. Trophic structure and productivity of Silver Springs, Florida. Ecol. Monogr. 27:55-112.

6. References Cited

Overton, W. S., and D. E. Davis. 1969. Estimating the numbers of animals in wildlife populations. pp. 403-455 In R. H. Giles, Jr. (Ed.). Wildlife management techniques. The Wildlife Society, Washington, D.C. 623 pp.

Partridge, L. 1978. Habitat selection. pp. 351-376 In J. R. Krebs and N. B. Davies (Eds.). Behavioral ecology: an evolutionary approach. Sinauer Associates, Inc. Sunderland, Massachusetts. 494 pp.

Pianka, E. R. 1974. Evolutionary ecology. Harper and Row Publishers. New York, New York. 356 pp.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill Book Company. New York, New York. 532 pp.

Ricklefs, R. E. 1973. Ecology. Chiron Press. Newton, Massachusetts. 861 pp.

Rogers, L. L., L. D. Mech, D. K. Dawson, J. M. Peek, and M. Korb. 1980. Deer distribution in relation to wolf pack territory edges. J. Wildl. Manage. 44(1):253-258.

Smith, R. L. 1974. Ecology and field biology. Harper and Row, Publishers. New York, New York. 850 pp.

Thomas, J. W., C. Maser, and J. E. Rodiek. 1978. Edges--their interspersion, resulting diversity and its management. pp. 91-100 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Trefethen, J. B. 1975. An american crusade for wildlife. Winchester Press and the Boone and Crockett Club. New York, New York. 409 pp.

Udall, S. L. 1963. The quiet crisis. Holt, Rinehart, and Winston. New York, New York. 266 pp.

U.S. Fish and Wildlife Service. 1976. Habitat evaluation procedures. Division of Ecological Services. Washington, D.C. vi + 30 pp.

U.S. Fish and Wildlife Service. 1980. Ecological Services Manual (101-104 ESM), Division of Ecological Services, Washington, D.C. Unnumbered.

Wagner, F. H. 1969. Ecosystem concepts in fish and game management. pp. 259-307 In G. M. Van Dyne (Ed.). The ecosystem concept in natural resource management. Academic Press. New York, New York. 383 pp.

6. References Cited

Watt, K. E. F. 1968. Ecology and resource management. McGraw-Hill Book Company. New York, New York. 450 pp.

Wiens, J. A. 1978. Nongame bird communities in northwestern coniferous forests. pp. 19-31 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Williams, J. B., and G. O. Batzli. 1979a. Competition among bark-foraging birds in central Illinois: experimental evidence. Condor 81:122-132.

Williams, J. B., and G. O. Batzli. 1979b. Interference competition and niche shifts in the bark-foraging guild in central Illinois. Wilson Bull. 91:400-411.

APPENDIX B

GUILDING APPROACH TO SPECIES SELECTION

GUILDING APPROACH TO SPECIES SELECTION *

When only a limited number of species may be evaluated, a guilding approach may be useful in providing a biological basis for species selection. A guild is defined as a group of species that utilize a common resource in the environment. Guilds can be defined in any level of detail, i.e., generalized with a large number of species or defined to the degree that each guild defines the niche of one species, or some level of detail in between. The advantages and disadvantages of using the guilding approach are summarized in Figure 1.3.

Advantages of Guilding

1. Allows an evaluation team to address the species that will be sensitive to the proposed land use; i.e., it provides a basis for a better assessment of project impacts.
2. Aggregation of species into guilds and the subsequent selection of representative species may allow inferences to be drawn about project impacts to other guild members, which may permit a more holistic evaluation of potential impacts with a manageable number of species.
3. Provides an ecological basis for impact assessment.
4. Provides documentation of the reasons behind the final selection of species to be evaluated.

Disadvantages of Guilding

1. The guilding process itself may be too time-consuming for a specific project.
2. Species selected to represent a guild may be unfamiliar to the general public.
3. Guilding may mask differences between species (depending on the level of detail used to define guilds).

Figure 1.3. Advantages and disadvantages of using the guilding process for species selection.

* U.S. Fish and Wildlife Service, 1985.

A prescreening process that considers expected impacts on cover types and guilds will help focus an evaluation on those species that are expected to be sensitive to project impacts. The first step in the prescreening process is to consider those cover types that will be impacted by a proposed action. For example, if project impacts will affect only wetlands and lowland agricultural lands, then species that use only the upland cover types need not be considered in a HEP analysis. Once potentially impacted cover types have been identified, then the guild concept can carry the prescreening process one step further. Although some project impacts may completely eliminate all guilds within a cover type (e.g., inundation of a forest), other impacts may not be uniformly distributed within a cover type. If impacts are concentrated on certain guilds (e.g., grazing impacts are concentrated on the terrestrial surface rather than in the tree canopy), then the HEP analysis should focus on those species that utilize those resources that are most likely to be impacted by a proposed action.

Five steps are involved in using the guilding process for species selection. These are:

(1) determine guild categories;
(2) identify guild descriptors;
(3) develop the guild matrices;
(4) enter candidate species into the appropriate cells of the guild matrices; and
(5) select evaluation species.

Step 1. Determine guild categories.

Terrestrial guild categories can be based on feeding and reproductive considerations, and the locations within the habitat where these activities occur. Aquatic guild categories may be based on reproductive and feeding considerations, tolerance to temperature changes or turbidity, preferred cover, or other categories.

Step 2. Identify guild descriptors.

Guild descriptors define the various levels of detail possible within each guild category (e.g., a feeding guild may inlude locational descriptors such as bottom feeders or water column feeders, or trophic level descriptors such as herbivore, planktivore, or carnivore). Guild descriptors should be identified to a level of detail appropriate to project impacts. For example, if the canopy of a forest will not be impacted by a proposed land use (e.g., grazing), then the use of tree canopy as a locational descriptor is unnecessary. On the other hand, if a proposed management action includes periodic burning of the ground cover, then this stratum should be included as one of the locational descriptors.

Step 3. Develop the guild matrix.

Guild descriptors are used to construct a matrix for each cover type likely to be affected by the proposed action. The matrix consists of cells which represent the potentially sensitive guilds within each cover type.

Step 4. Enter candidate species into the appropriate cells of the guild matrix.

Potentially impacted species should be entered into the appropriate matrix cells. Some cells may contain several species. A cell may not contain any species because no potentially impacted species logically occurs in that guild. An individual species may be placed in more than one cell (e.g., the white-tailed deer may feed in both the shrub stratum and the terrestrial surface stratum).

Ideally, all species that are potentially sensitive to project impacts should be considered. Practically, however, this may be too time-consuming if a large number of species are involved. At a minimum, enough species should be considered such that at least one species occurs in each guild

cell, if at all possible. The judgement of the HEP team is required in limiting the number of species considered beyond the minimum.

Step 5. Select evaluation species from the guild matrices.

The final step in this approach is the actual selection of evaluation species. Ideally, one species should be selected from each guild. Where several species occur within a guild, selection criteria may be established for prioritizing species within the guild. Selection criteria should be developed by the evaluation team. Examples of selection criteria are presented in Figure 1.4. The species perceived to be most important in light of the selected criteria should be selected to represent each guild.

Within-Guild Selection Criteria	Rating
Anticipated sensitivity to potential project impacts:	
• Highly sensitive to proposed water and land use changes	4-5
• Moderately sensitive to proposed changes	2-3
• Insensitive to proposed changes	1
2. Limitation of geographic range:	
• Extremely limited range largely confined to the project area	5
• Moderately limited range but also found outside the project area	2-4
• Broad geographic range beyond the project area	1
3. Availability of habitat data:	
• Species-habitat relationships well documented with data	4-5
• Species-habitat relationships partially documented	2-3
• Species-habitat relationships not well documented	1

Figure 1.4. Examples of selection criteria that may be used to rank species within guilds.

INFERENCES FROM EVALUATION SPECIES TO OTHER SPECIES

An impact assessment based on HEP is directly applicable only to the species selected for evaluation. One of the advantages to guilding, however, is that it provides the opportunity to use predicted impacts on selected species to predict impacts on other species. The extent to which such inferences may be made depends on both the perceived impacts to the evaluation species and the level of detail used to define the guild(s).

Inferences may be made from the predicted impacts on an evaluated species to other species if they all share a common resource that is being impacted. For example, an evaluation may indicate a loss of habitat units for a raptor as the result of a predicted reduction in the prey base. Such an impact can be safely extrapolated to other species that also depend upon the same prey base. On the other hand, a reduction in habitat units for the white-tailed deer may be due to a loss of winter cover. Inferences cannot be made that other species in the same feeding guild (e.g., eastern cottontails in grasslands) will be similarly affected, since the predicted impacts affect deer cover rather than food.

If predicted impacts are due to changes in resources shared by several species, then possible extrapolation from impacts on an evaluated species to non-evaluated species will depend on the level of detail used to define common resources in the guild(s). If the guild descriptors define broad guilds (e.g., all carnivores), then inferences may be made but with low confidence. The greater the level of detail used in describing guilds, the greater will be the level of confidence with which inferences may be made. For example, if carnivores are separated into those that feed on vertebrates and those that feed on invertebrates, then inferences from an evaluated species to other species within the guild can be made with a greater degree of confidence than would be possible if the guild was described by the general category of carnivore.

REGIONAL GUILDS

It may be desirable to construct guilds for all species within a region and develop a tentative list of candidate evaluation species. Although the initial investment of time may be considerable, the list could be used for species selection on numerous projects. In regions where numerous projects are anticipated, the initial guilding of all species in the region may be an efficient use of both time and money. Since study objectives will vary between projects, it may be desirable to construct several lists with different levels of guild descriptor detail. There would then remain only the task of each evaluation team to develop project specific selection criteria with which to make the final selection of evaluation species.

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Phase II Final Technical Plan
(Version 3.2)
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

SECTION II - PHASE II TECHNICAL PLAN
TABLE OF CONTENTS
(Page 1 of 3)

SECTION II - PHASE II TECHNICAL PLAN
TABLE OF CONTENTS
(Continued, Page 2 of 3)

SECTION II - PHASE II TECHNICAL PLAN
TABLE OF CONTENTS
(Continued, Page 3 of 3)

SECTION II - PHASE II TECHNICAL PLAN
LIST OF FIGURES

SECTION II - PHASE II TECHNICAL PLAN
LIST OF TABLES

1.0 INTRODUCTION

1.1 LOCATION AND HISTORY

Rocky Mountain Arsenal (RMA) occupies about 27 square miles of Adams County, Colorado and is located about 10 miles northeast of the city of Denver (Figure 1.1-1). RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982 (USATHAMA, 1984, RIC#84034R01).

A number of changes have occurred since the establishment of RMA. Over 1,000 acres were altered for industrial, commercial, and residential purposes. During the 1940's a portion of RMA was leased for agricultural uses, and crops such as wheat and corn were planted for game habitat improvement. A large area in the northern part of RMA was planted with wheat for the production of biological agents during the 1960's. Approximately 2,800 acres were leased for cattle grazing in the late 1960's. Over time, large areas have been planted with crested wheatgrass. In addition, trees and shrubs have been planted around buildings and along roadsides.

During the period from approximately 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired 10.7 centimeter (cm) mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II (WWII) ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company (Hyman). CFI manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Hyman produced a variety of pesticides, including insecticides and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company (Shell) assumed the Hyman lease. Manufacturing by Shell ceased in 1982, and the Shell lease expires in 1987.

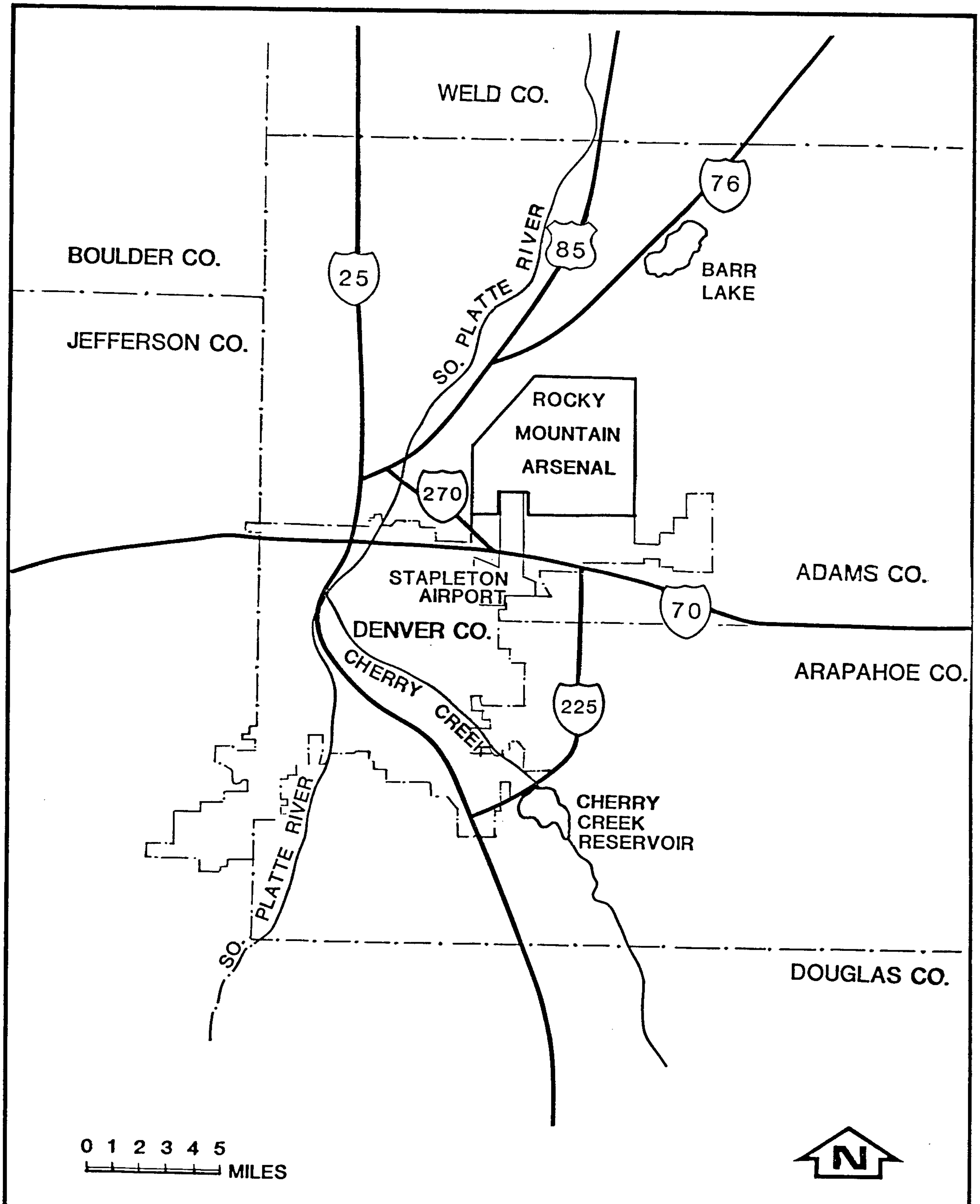


Figure 1.1-1
ROCKY MOUNTAIN ARSENAL
LOCATION

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Construction of facilities for the production of GB nerve agent began in 1950 and was completed in 1953. Manufacture of GB was continued until 1957 and GB munitions filling operations continued until late 1969 (USATHAMA, 1984, RIC#84034R01).

Basin A, located within Section 36 (Figure 1.1-2), was the original disposal area for waters and waste waters resulting from all RMA and industrial operations. Basin A was selected because it was part of a natural depression. In 1952, the impoundment dike was raised 5 feet (ft) to handle additional waste generated after the GB plant went into operation. During the period from 1943 to 1956, Basin A was the primary receptor of liquid waste. Overflows went through the open drainage to Basins B, C, D, and E, constructed in 1952. Basin F was completed in 1957 to contain all waste waters, and liquids in Basin A were transferred to it by 1958.

During the period from 1965 to 1969 demilitarization of phosgene and cyanogen chloride munitions was performed at RMA. Disposal of mustard munitions occurred from 1972 to 1974, and demilitarization of GB munitions was performed from 1973 to 1976.

Disposal practices at RMA have included routine discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In addition to these practices, unintentional spills of raw materials, process intermediates, and final products have occurred within the manufacturing complexes at RMA. Many of these compounds are mobile in surface and ground waters as well as air.

1.2 ENVIRONMENTAL SETTING

RMA occupies over 17,000 acres (27 square miles) of low, rolling terrain with grasslands, shrublands, wetlands, aquatic habitats, and extensive weedy areas supporting a number of plant and wildlife species. The South Platte River flows parallel to the northwest boundary and is less than 2 miles from RMA. The area surrounding RMA is largely ranch/farmland, rural and urban residential, and industrial (Kolmer and Anderson, 1977, RIC#81295R07).

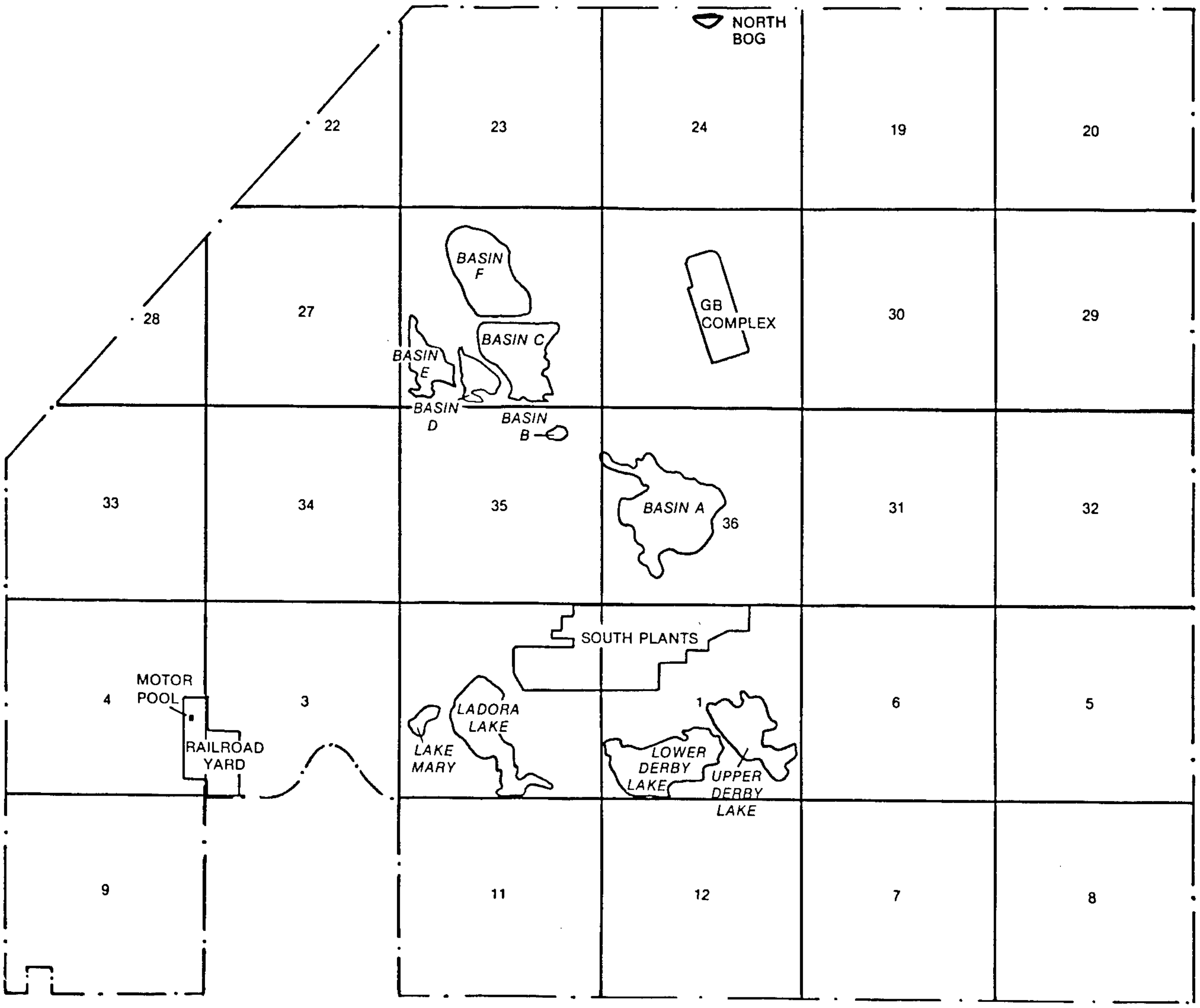


Figure 1.1-2
MAP OF ROCKY MOUNTAIN ARSENAL
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

The adjacent land north of RMA consists mostly of rangeland (grassland) and dryland agriculture. Rural residential developments are scattered north and northwest of RMA. Urban developments include Commerce City (west) and Montbello (south). The north runways of Denver's Stapleton International Airport extend into the southwestern corner of RMA.

Cropland and range habitat north and east of RMA provide habitat for game species such as cottontails, ring-necked pheasants, and mourning dove. Lake and wetland areas at Barr Lake, five miles to the northeast and downstream from RMA, provide staging, breeding, and resting areas for waterfowl; habitat for edible fish species; and winter habitat for the the bald eagle, an endangered species.

1.2.1 TOPOGRAPHY

The topography of RMA consists of stream-valley lowlands separated by gently rolling uplands. The maximum local topographic relief in the area is about 300 ft; the elevation above mean sea level (msl) ranges from about 5,330 ft at the southeastern boundary of RMA to about 5,029 ft at the northwestern boundary of RMA. The average elevation across RMA is 5,250 ft msl.

Tributaries from RMA to the South Platte River drain to the northwest, while the overall surface drainage in the region is toward the northeast, and all of RMA is drained by the South Platte River and its tributaries. The South Platte River originates in the Rocky Mountains southwest of Denver, and then flows in a general north-northeast direction to the vicinity of Greeley, where it swings toward the east.

RMA contains parts of five different drainage basins as shown in Figure 1.2-1. Proceeding from southwest to northeast, these basins are Sand Creek, Irondale Gulch, Basin A, First Creek, and Second Creek. All these areas are sub-basins in the South Platte River drainage. The South Platte River flows northeasterly at a distance of approximately 4.8 kilometers (km) from the RMA northwest boundary.

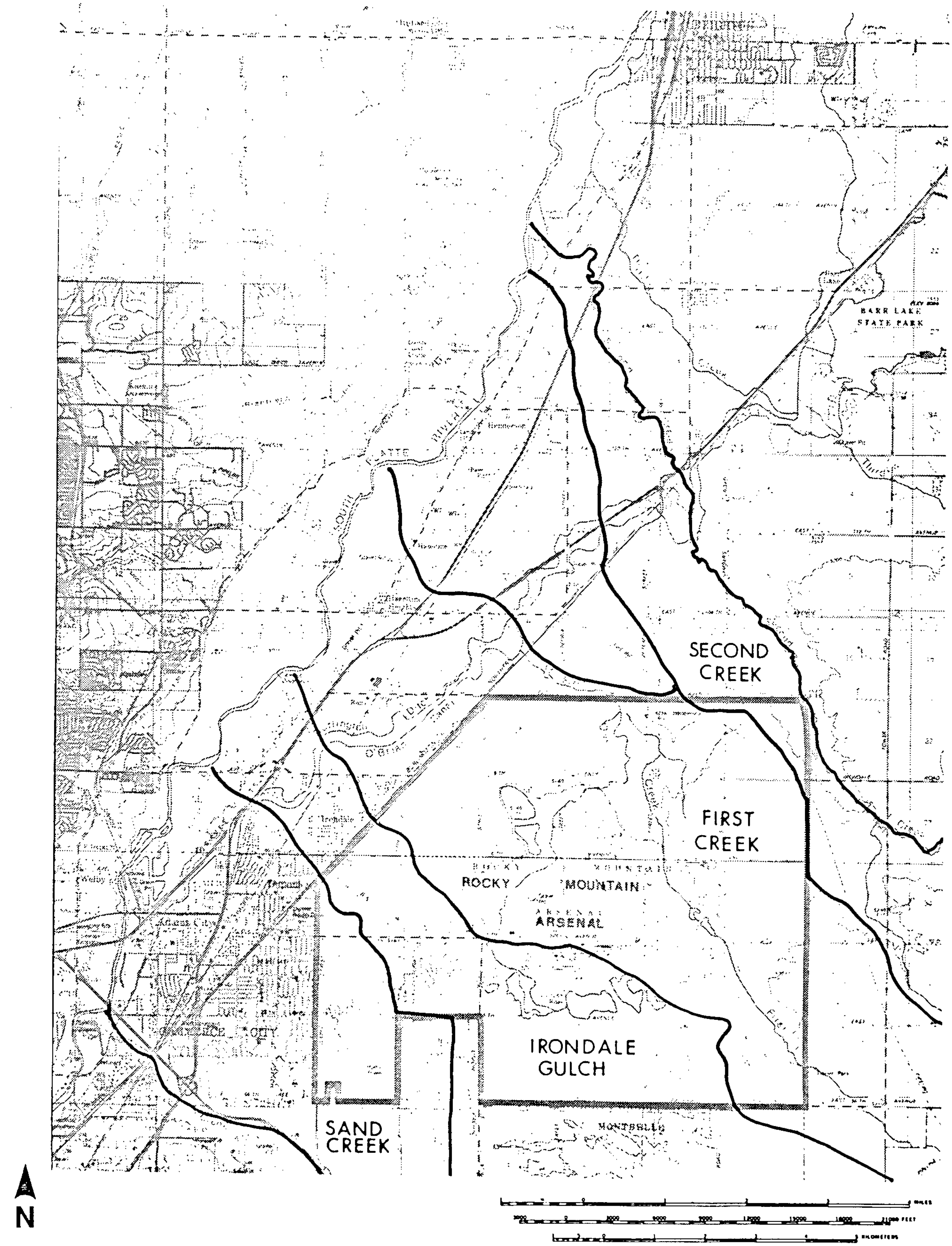


Figure 1.2-1
SURFACE WATER DRAINAGE BASINS
SOURCE: RESOURCE CONSULTANTS, 1981

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Two major irrigation canals, O'Brian Canal and Burlington Ditch, and several smaller ditches run southwest to northeast between RMA and the South Platte River. O'Brian Canal and Burlington Ditch receive drainage from RMA by interception of First and Second Creeks. These flows are either stored in the reservoir at Barr Lake State Park or distributed into one or more of many irrigation ditches downstream, depending on the season and the quantity of water available.

1.2.2 GEOLOGY

RMA is located in the northwestern portion of the Denver Basin, an oval shaped structural depression, 120 miles long and 70 miles wide. Sediments up to 15,000 ft thick within the basin are composed of sandstone, shale, conglomerate, and limestone. These are overlain by a relatively thin veneer of recent alluvial and aeolian deposits. The major units at RMA include the recent alluvial and aeolian deposits and the underlying Denver Formation. The alluvial and aeolian deposits, often referred to simply as alluvium, consist of Quaternary age interbedded unconsolidated sands, silts, clays, and gravels. These deposits generally range from 10 to 40 ft thick over most of RMA. Thicknesses up to 130 ft have been encountered along buried channels that traverse RMA in a generally northwest direction.

The Denver Formation underlies the surficial materials at RMA. The Denver Formation consists of 400 to 600 ft of clay shale and lenticular bodies of sand and thin zones of silt, clay, lignite, coal, siltstone, sandstone, and volcaniclastic sediments. The clay shale is a hard, bentonitic unit that varies from blocky to laminated in appearance. The sand lenses are composed predominantly of poorly cemented sandstone which grades laterally and vertically into silts and clay shales.

There are two aquifers of primary concern at RMA, the alluvial aquifer and the Denver aquifer. The alluvial aquifer, also termed the upper aquifer, consists of interbedded sands, silts, clays and gravels of alluvial and aeolian origin. The contact between these deposits and the underlying Denver Formation is often marked by a zone of weathered

bedrock. Where present, this zone is considered to be part of the alluvial aquifer system.

The Denver aquifer, also referred to as the lower aquifer, bedrock aquifer or Denver sands, is composed primarily of lenses of weakly cemented sandstone or compact fine to medium grained sands. These sand lenses are discontinuous, grading laterally and vertically into relatively impermeable silts and clay shales.

1.2.3 CLIMATE

A sunny, semi-arid climate prevails over much of the central Rocky Mountain region, without the extremely cold mornings of the high elevations and restricted mountain valleys during the cold part of the year, or the hot afternoons of summer at lower altitudes. Extremely warm or cold weather is usually of short duration. Air masses from at least four different sources influence the area weather: arctic air from Canada and Alaska, warm moist air from the Gulf of Mexico, warm dry air from Mexico and the southwest, and Pacific air modified by its passage over coastal ranges and other mountains to the west.

Spring is the wettest, cloudiest, and windiest season. Approximately 37 percent of the total annual precipitation (normal = 15.53 inches) occurs in spring. Much of this moisture falls as snow during the colder, earlier period of the season.

Summer precipitation (31 percent of the annual total), particularly in July and August, comes mainly from scattered local thunderstorms during the afternoons and evenings. In autumn, there is less cloudiness and a greater percentage of sunshine than at any other time of the year. Precipitation amounts to about 19 percent of the annual total.

Winter has the least precipitation accumulation, only approximately 13 percent of the annual total, and almost all of it is snow. Precipitation frequency, however, is higher than in autumn. There is more cloudiness, and the relative humidity averages higher than in the autumn.

Temperature and precipitation normals, means, and extremes are summarized in Table 1.2-1 (Fairbanks and Kolmer, 1976, RIC#84219R01; Kolmer and Anderson, 1977, RIC#81295R07). These data were collected at the Weather Bureau Office at Stapleton International Airport which borders a part of the RMA south boundary.

1.2.4 BIOTA

Several distinct vegetation types occur on RMA and are classified into three major ecosystem types: terrestrial, wetland, and aquatic. Over 200 plant species have been documented on RMA. Disturbed shortgrass prairie, mixed grasslands, and crested wheatgrass predominate on much of the northern portions while lakes, wetlands, and small patches of woodland occur within the southern section. Indigenous and introduced plants on and near RMA are mostly common species found throughout the region. Figure 1.2-2 shows the distribution of vegetation types on RMA based on aerial photography, existing maps, limited ground-truthing, and reference to the draft vegetation map provided by Morrison-Knudson Engineers, Inc. (MKE).

Overall, nonnative herbaceous plants are the most widely distributed vegetation. This cover vegetation occurs on at least 80% of the land area at RMA, and reflects both past disturbance and present land management practices. Weedy species seen commonly to invade recently disturbed areas at RMA include cheatgrass, prickly lettuce, tumble-mustard, kochia, Russian thistle, bindweed, western ragweed, prairie sunflower, and horseweed (Kolmer and Anderson, 1977, RIC#81295R07; ESE field studies). Crested wheatgrass occurs mixed within this weedy community, or often in pure stands, as it has been planted. Areas observed to be predominantly crested wheatgrass (as of 7/86) are shown in Figure 1.2-2 as "Crested Wheatgrass".

The native herbaceous plant group is present on about 7 percent of the area. Blue grama is the most abundant species, often forming a dense sod with such mid-grasses as squirreltail, sand dropseed, or red threeawn as co-dominants. Common forbs include copper-mallow, prairie sunflower, and sand lily.

Table 1.2-1. Temperature and Precipitation Normals, Means, and Extremes Recorded at Stapleton International Airport

Month	Temperatures °F Normal Daily Maximum	Normal Daily Minimum	Record Highest	Record Lowest	Precipitation in Inches Normal Monthly	Maximum Monthly	Mean Monthly Snow
January	43.5	16.2	69	-25	0.61	1.44	8.2
February	46.2	19.4	76	-18	0.67	1.66	7.9
March	50.1	23.8	84	- 4	1.21	2.89	12.7
April	61.0	33.90	84	- 2	1.93	4.17	9.9
May	70.3	43.6	93	26	2.64	7.31	1.6
June	80.1	51.9	98	36	1.93	4.69	Trace
July	87.4	58.6	103	43	1.78	6.41	0.0
August	85.8	57.4	100	41	1.29	4.47	0.0
September	77.7	47.8	97	20	1.13	4.67	1.8
October	66.8	37.2	87	3	1.13	4.17	3.7
November	53.3	25.4	78	- 2	0.76	2.97	7.9
December	46.2	18.9	73	-18	0.43	2.84	6.4
YEAR	64.0	36.2	103	-25	15.51/yr	7.31	60.1/yr

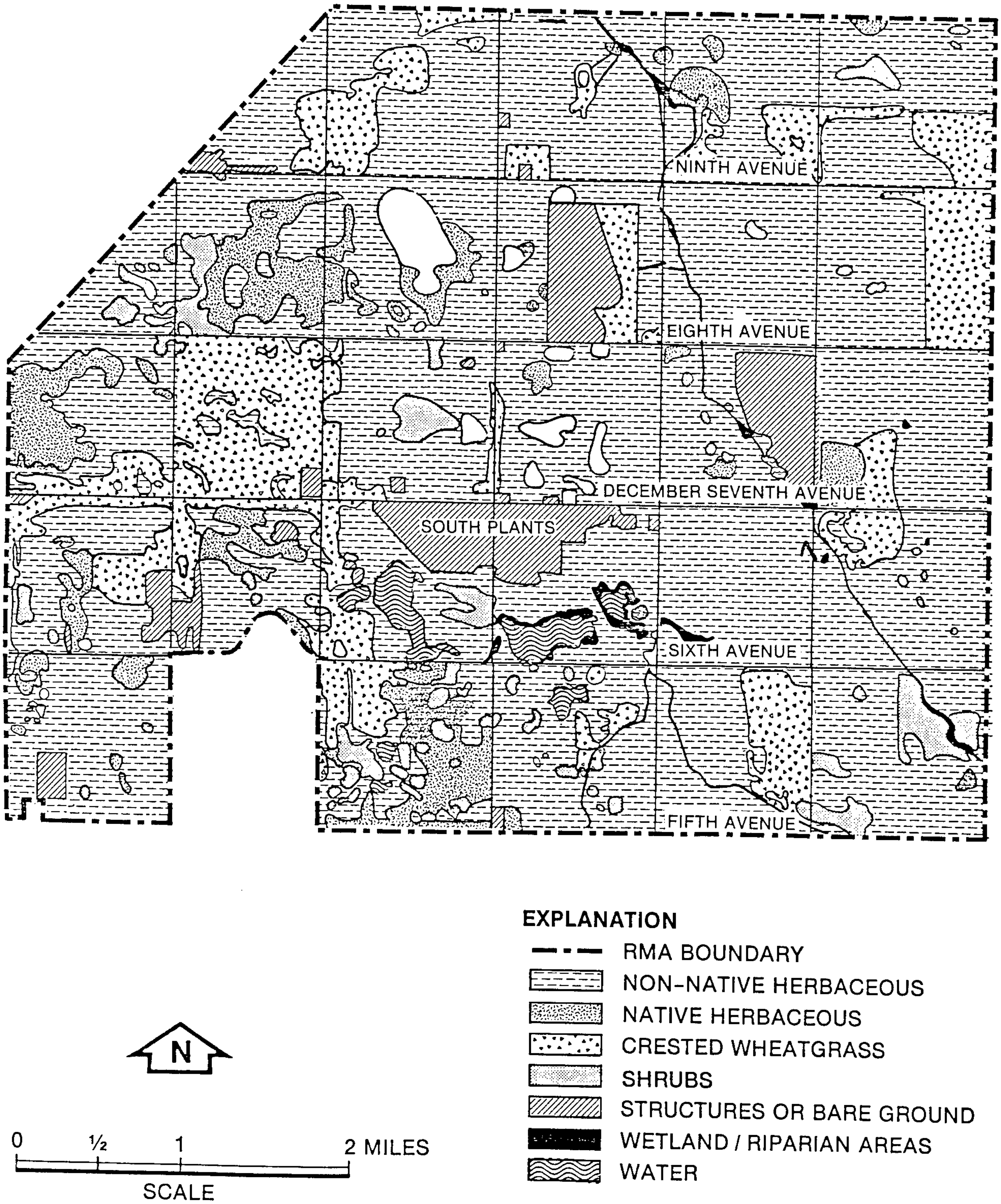


Figure 1.2-2
PRELIMINARY VEGETATION MAP OF ROCKY MOUNTAIN ARSENAL

SOURCE: ESE, 1986

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Upland shrubs and scattered woodlands constitute about 4 percent of RMA property. Dense, nearly impenetrable, pure stands of locust dot the plains at RMA. These thickets developed from locusts planted by the early settlers. Most are from 5 to 20 ft in height, with a low diversity of understory vegetation. Dense willow thickets are scattered along water courses at RMA. The small woodlands consist of scattered trees around old farmsteads, along roads, windbreaks, and in riparian areas. These woodlands contain a variety of trees including Chinese elm, plains cottonwood, white poplar, Rocky Mountain juniper, ponderosa pine, and box elder (Fairbanks and Kolmer, 1976, RIC#84219R01).

Wetland and riparian vegetation comprises less than 2 percent of the surface area at RMA. It is found in patches along First Creek, some of the canals, the lakes and ponds, and other low-lying moist areas. Cattails are abundant in shallow water or very wet areas. Smartweed, sedges, and American bulrush are locally common in these areas. On moist areas alkali salt-grass or squirreltail may form a dense cover. Lakes and ponds containing aquatic vegetation represent about one percent of the area and are concentrated in the southern portion of RMA (Kolmer and Anderson, 1977, RIC#81295R07).

Approximately 7 percent of the land area at RMA has been developed or is otherwise devoid of vegetation. This includes the large, industrial complexes as well as small, commercial and residential areas. Waste disposal areas lacking vegetation are also included.

The great variety of vegetation present on RMA provides cover, food, and reproductive habitat for many wildlife species. Four hundred and seventy-one vertebrate species potentially occur on RMA property (Appendix A). These include 25 fish, 7 amphibian, 23 reptile, 361 bird, and 55 mammal species. Migratory as well as resident wildlife are represented. In addition, a diversity of invertebrate species are represented from collections at RMA.

Populations of game fish including largemouth bass, black bullhead, northern pike, channel catfish, and bluegill inhabit the lakes and ponds in the southern part of RMA. Most of these have been stocked or have been introduced via irrigation canals (Kolmer and Anderson, 1977, RIC#81295R07).

RMA supports a variety of amphibians and reptiles. Of the 30 species listed, population levels are considered at least fairly common for 24 species and uncommon or unknown for six species (CDOW, 1981). The bullsnake may be the most abundant reptile throughout RMA, while the lesser earless lizard is common in exposed sandy areas and the plains garter snake is common in marsh or moist habitats. The prairie rattlesnake inhabits grassland areas.

Populations of bullfrogs are found around the permanent lakes of RMA. Other common amphibians include the chorus frog, plains spadefoot, northern leopard frog, and tiger salamander.

A great diversity of bird life, including songbirds, shorebirds, water birds, upland gamebirds, and raptors are found on RMA. Some abundant breeding birds of the prairie habitats of RMA include the western meadowlark, lark bunting, horned lark, mourning dove, Brewer's sparrow, and ring-necked pheasant (CDOW, 1982). The lark bunting and horned lark are primarily restricted to shortgrass vegetation, such as the blue grama and red threeawn vegetation cover types, while the Brewer's sparrow is common only in areas with scattered shrubs. During winter, the western meadowlark, horned lark, and ring-necked pheasant are among the dominant prairie species.

The scattered trees, thickets, and woodlands of RMA provide nesting habitat for black-billed magpies, eastern and western kingbirds, house wrens, starlings, northern orioles, common grackles, and many others. The American tree sparrow, white-crowned sparrow, dark-eyed junco, starling, black-billed magpie, and yellow warbler are common wintering birds of the woodland habitat.

The lakes, ponds, and marshes of RMA support many species of aquatic and marsh birds. Common breeding birds include several species of waterfowl, red-winged and yellow-headed blackbirds, and common yellowthroats. Many species of waterfowl, including large numbers of Canada geese, as well as other birds, utilize these habitats during the winter.

In addition to supporting the typical breeding birds of eastern Colorado, RMA supports breeding populations of several species which breed only locally or rarely on the eastern plains. The short-eared owl, tree swallow, mockingbird, sage thrasher, orchard oriole, grasshopper sparrow, and Brewer's sparrow, as well as other species, are in this category (CDOW, 1982a).

Another unique characteristic of RMA is the density of raptors present on the installation. The abundance of prey, the distribution and abundance of suitable nesting and perching habitat, and the relative lack of human disturbance favor high population densities of hawks and owls. Previous winter surveys showed that hawk densities averaged approximately five to six individuals per square mile (Kolmer and Anderson, 1977, RIC#81295R07). Rough-legged hawks are abundant during the winter, as are ferruginous and red-tailed hawks. Golden eagles and bald eagles also winter on RMA. Wintering owls include long-eared, short-eared, barn, and great-horned. During the summer, red-tailed and Swainson's hawks, Northern harriors and American kestrels are common. The latter three species are the dominant breeders. Great-horned, long-eared, short-eared, and burrowing owls are also common breeders. The bald eagle, a federal endangered species, has been observed for several years as a winter resident at RMA. Recent census work by ESE suggests that up to 20 bald eagles may spend portions of the winter there.

Several groups of mammals are represented at RMA. Rodents (25 species) and carnivores (13 species) are the most diverse groups. Although some species are rare or uncommon, most are fairly common (CDOW, 1982).

Previous small mammal trapping has indicated that large densities of certain species may be present in some areas. Among the most abundant

are deer mice, prairie and meadow voles, and Ord's kangaroo rat. The larger, more conspicuous rodents include the black-tailed prairie dog, thirteen-lined ground squirrel, and fox squirrel. RMA contains large acreages of prairie dog towns (Kolmer and Anderson, 1977, RIC#81295R07). Another abundant rodent, the plains pocket gopher, is conspicuous due to the mounds of soil it produces at the surface when it excavates its underground tunnels. The densities of this small mammal are highest in areas with sandy soils.

Lagomorphs are conspicuous and abundant on RMA. Black-tailed jackrabbits are widespread, being especially common in areas with tall grass, forbs, or shrubs. Cottontail rabbits are common in and around woodlands, thickets, brush piles, and prairie dog towns.

The mule deer is the most common big game mammal on RMA. Recent aerial counts by the Colorado Division of Wildlife (CDOW) (December 1986) indicated at least 133 mule deer were present within Arsenal boundaries. Division personnel also counted 22 white-tail deer at RMA (these data were not available at the time the draft technical plan was prepared).

The most abundant predatory mammals on RMA are the coyote, badger, and long-tailed weasel. Coyotes are frequently observed, especially in winter. The CDOW December 1986 census indicated at least 10 coyotes inhabit RMA.

The black-footed ferret is the only threatened or endangered mammal that may have once occurred at RMA. No confirmed sightings in the RMA vicinity have occurred since 1914, and nocturnal spotlight searches in 1975 found no evidence of ferrets (Kolmer and Anderson, 1977, RIC#81295R07).

Although systematic studies have not been made, regional and site literature indicate that a diversity of invertebrate species exists at RMA. Representatives of 48 insect families have been collected at RMA since 1975 and species from 11 other families of invertebrates have been identified.

Grasshoppers (Orthoptera) are a major food source for many of the birds and mammals found on RMA (Martin et al., 1951). They are abundant throughout summer and occasionally become so dense that they do considerable damage to the vegetation.

Other common invertebrate residents of the prairie of RMA are the harvester ants. They denude the vegetation in circles up to 20 ft or more in diameter around their mounds. They collect and store large quantities of seeds and are used as food items by many amphibians, reptiles, birds, mammals, and other insects.

Beetles (Coleoptera); moths and butterflies (Lepidoptera); bees, wasps, and ants (Hymenoptera); and other invertebrates are abundant and important organisms in the natural environment at RMA. They are important in the decomposition of organic matter, as food sources for other animals, for the pollination of many plants, and for aeration of soil (Kolmer and Anderson, 1977, RIC#81295R07).

1.3 PROBLEM DESCRIPTION

There are numerous sites on RMA where hazardous wastes have been intentionally deposited or that have become accidentally contaminated due to past Army and lessee activities. Industrial waste effluents generated at RMA were routinely discharged to unlined evaporation basins. Solid wastes have been buried at various locations throughout RMA. Unintentional spills of raw materials, intermediate and final products have occurred within the manufacturing complexes at RMA. Contaminants from these sites have occasionally entered mobile media (ground water, surface water, air, or animals) and may have been transported off RMA limits.

Deaths and abnormal behavior have been recorded for several waterfowl species in the lower lakes on RMA (Jensen, 1955, RIC#84292R04). Subsequent observations and testing indicated that ducks found dead, dying, or displaying unusual behavior (e.g., flying into buildings) contained high levels of dieldrin and other organochlorine compounds. Since that time, high levels of organochlorines have also been found in

fish from the lower lakes, in raptors collected on and near the RMA, and in the flesh of other game animals including ringneck pheasant, mourning dove, and cottontail rabbits.

Chemical analyses of fish and wildlife have been conducted on an annual basis from the early 1970s to the present. These studies have revealed that at least some of the waterfowl, fish, and other fauna from RMA contain levels of pesticides and metals (e.g., mercury) in their flesh which pose a potential health hazard to humans who consume them. These contaminant levels could adversely affect wildlife by lowering reproductive success, decreasing hatching success of waterfowl, and causing the premature death of young individuals.

In 1954 and 1955, farmers to the northwest of RMA reported crop losses due to use of well water for irrigation. Two contaminants, diisopropylmethylphosphonate (DIMP), which is a by-product of manufacture of GB nerve agent, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost ground water in 1974. Since 1974, offpost migration of dibromochloropropane (DBCP), a nematocide which had been shipped from RMA by rail from 1970 to 1975, has been observed in ground water.

Shallow ground water contamination exists in areas north and west of RMA, in part, as a result of onpost activities. Well water in contaminated offpost areas is used to water vegetable crops which are grown for local sale and consumption. Livestock are watered from some of these wells, and are also fed crops raised in the area. Ground water contamination thus poses a potential hazard to livestock and humans as well as wildlife in the offpost area.

Past investigations have documented a variety of injuries to the biota at RMA. This plan provides the comprehensive assessment needed to determine the species affected, chemicals and areas of concern, and the extent and nature of past and current injuries to biota resources and to the services provided by these resources for purposes of the remedial investigation/feasibility study.

1.4 OBJECTIVES AND REGULATORY REQUIREMENTS

1.4.1 GENERAL OBJECTIVES

The overall objective of the biota assessment is to provide information necessary for the evaluation of current and past hazardous waste effects on biological resources on and related to RMA. This information is to be obtained from existing documents, contacts with regional experts and other knowledgeable individuals, and from sampling programs instituted to acquire data not already available from other sources.

The activities of this task will be used to:

- Fulfill the U. S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study (RI/FS) requirements for biota studies of hazardous waste sites under the National Contingency Plan (NCP);
- Provide specific information on the migration and accumulation of contaminants through regional food webs; and
- Generate information that may have utility in the context of the Natural Resource Damage Assessment required by CERCLA.

The regulatory requirements for biological studies at RMA in relation to hazardous waste assessment are described in the following sections.

1.4.2 NATIONAL CONTINGENCY PLAN

A Remedial Investigation/Feasibility Study (RI/FS) is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 50 Fed. Reg. 479112 (November 20, 1985). This study is to be undertaken by the lead agency conducting the remedial action in order to determine the nature and extent of the threat presented by the contamination and to evaluate possible remedies. The study design includes appropriate sampling, monitoring, and exposure assessment as necessary, and requires the gathering of sufficient information to determine the necessity for and proposed extent of remedial action. The NCP also requires an analysis of food chain contamination and bioaccumulation. While extensive statistically valid ecological monitoring is not required, it is necessary to examine potential food chain contamination and to estimate the extent of any food chain contamination problem (50 Fed. Reg. 47925).

1.4.3 NATURAL RESOURCE DAMAGE ASSESSMENT REGULATIONS

CERCLA § 301(c), 42 U.S.C § 9651(c), provides for the issuance of regulations for the assessment of damages for injury or destruction of, or loss of natural resources resulting from a release of a hazardous substance. Accordingly, Natural Resource Damage Assessment (NRDA) regulations were promulgated, 51 Federal Register 27674 (August 1, 1986), to provide a cost-effective means of assessing any compensatory damages which may be warranted for injuries residual to those injuries that may be ameliorated in the response action. In essence, these regulations provide for the initiation of the NRDA process upon the lead agency's notification of each Federal or State agency authorized to act as trustee(s) of the potential existence of natural resource injury, with a preassessment screen occurring thereafter. In the event that a type B NRDA is then found to be warranted, this would involve a three-phase process:

1. Establishing that the injury occurred and that the injury resulted from the discharge or release;
2. Quantifying the effects of the discharge or release on the services provided by the injured resource; and
3. Determining the damage.

During the post-assessment phase, procedures would be implemented for the issuance of the Report of Assessment, to provide a demand for a sum certain to a responsible party, and for the establishment of a restoration account.

Although the Army has not initiated the formal NRDA process as of this time, this "Biota Assessment Phase II Technical Plan" contemplates utilizing data gathered during the biota assessment for purposes of the NRDA whenever appropriate. Thus, it is intended that this NCP biota assessment will also be consistent with the NRDA process to the maximum extent possible.

1.4.4 STUDY COORDINATION

The major participants in the biota assessment portion of RI/FS studies at RMA include the U.S. Army, as lead agency of the site and its

contractor, ESE, Inc.; Shell Oil Company and its environmental contractor, MKE; and the State of Colorado represented by the Department of Health and the Division of Wildlife. Procedures for the regular exchange of data, coordination of environmental studies, and review of study plans will be conducted in accordance with the parties' long-term arrangements. A Biota Assessment Committee has been established to facilitate the process and serves as an official subcommittee of the MOA group.

2.0 EVALUATION OF EXISTING INFORMATION

2.1 CONTAMINATION SITES AND SOURCES

Numerous studies have been conducted in relation to particular contamination problems in the three decades since the discovery of chemical contamination in the environment on and near RMA. Recent summary documents have provided an overview of the history of contamination at RMA. Potential sites of contamination have been identified on RMA (USATHAMA, 1984). Additional investigations have been performed in relation to the known and potential migration of chemical contaminants from RMA by means of ground water (USATHAMA, 1983). Data provided in these documents was the result of investigations conducted at different locations, different times, and involving the analysis of different groups of chemicals. The results of these studies identified more than 100 discrete sites of potential contamination and/or contaminant migration on RMA (Figures 2.1-1 and 2.1-2).

Comprehensive investigations of contaminant distribution are presently underway which are aimed at identifying the locations, types, and concentrations of contaminants in the environment on and near RMA. When completed, the first phase of data collection for surface water, ground water, and soil will provide an overview of contamination in these media. Additional assessment studies of contamination in air and in the biota are presently under way. When completed, these will provide a comprehensive evaluation of the nature and extent of environmental contamination resulting from activities associated with the RMA.

2.1.1 SITE IDENTIFICATION

Potential sites of contamination which affect or have affected biota were selected on the basis of existing information. The description of sites of potential contamination and potential contaminant migration were reviewed to determine the known or probable chemical contaminants associated with each location. Data on the amount, toxicity, and persistence of these chemicals were examined for each site. These data are discussed further in Section 2.2.

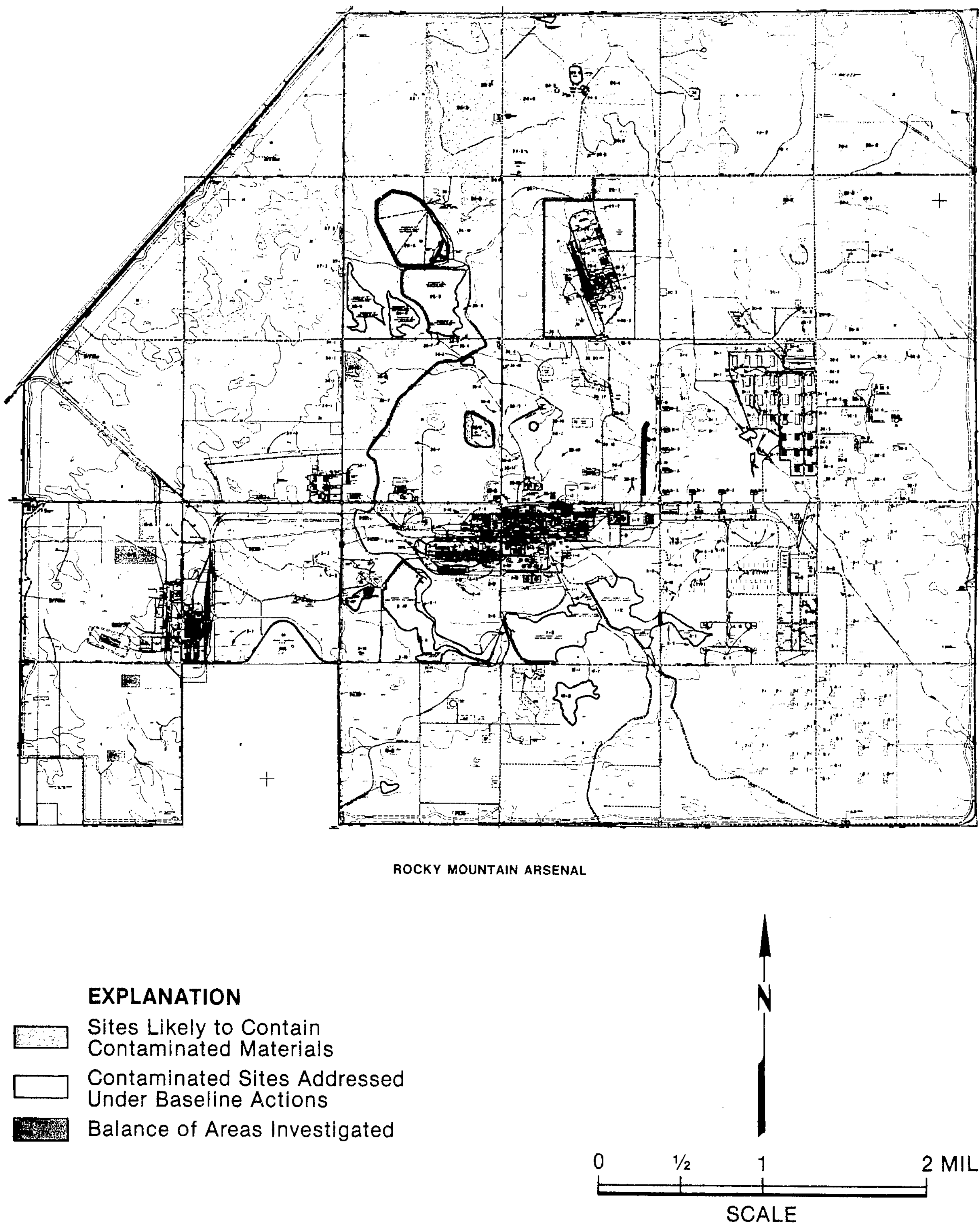
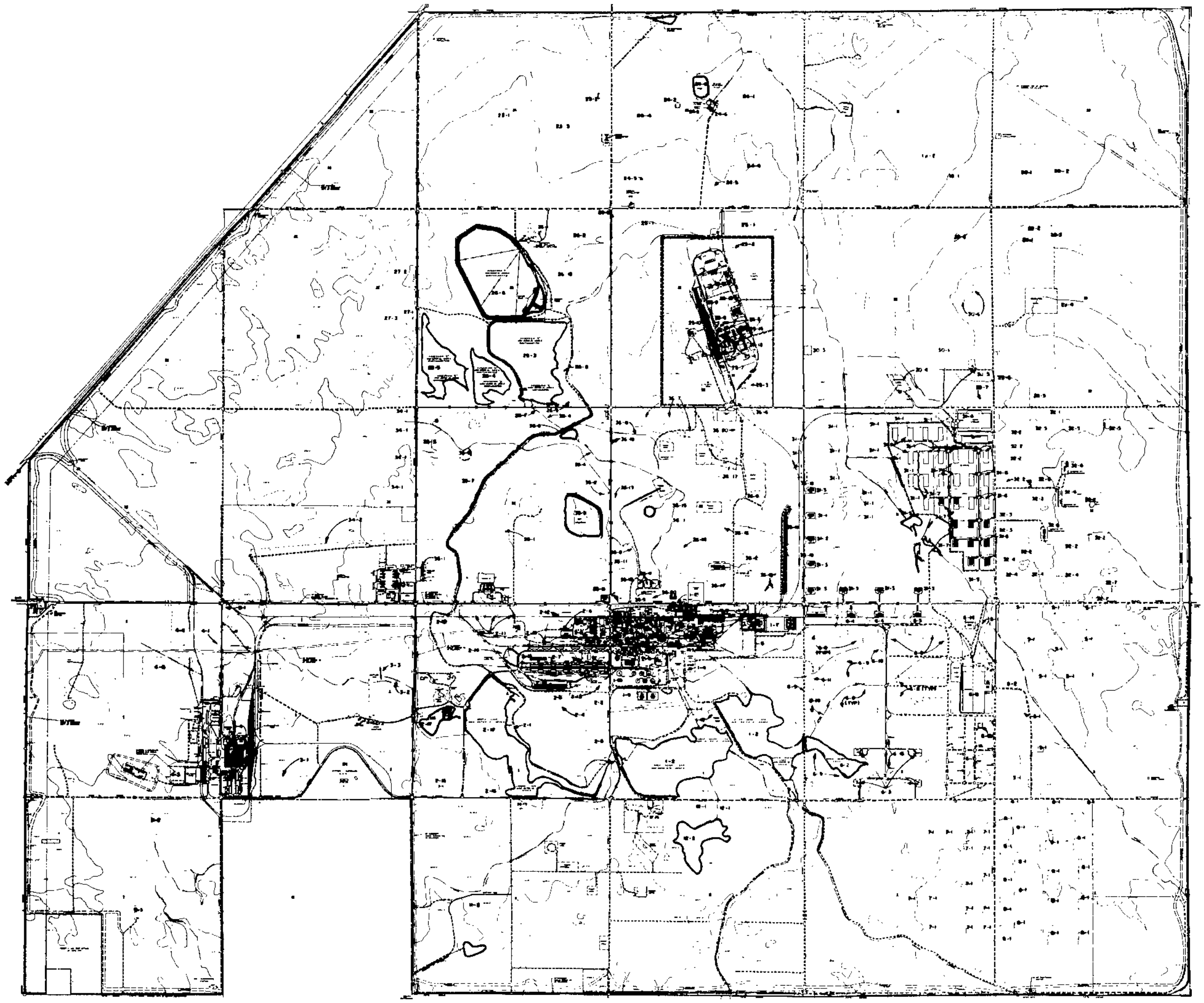


Figure 2.1-1
AREAS INVESTIGATED AS POTENTIAL CONTAMINATION SITES ON RMA

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal

Aberdeen Proving Ground, Maryland



ROCKY MOUNTAIN ARSENAL

EXPLANATION

- Primary Migration Source
- Potential Migration Source
- Balance of Areas Investigated

N

0 ½ 1 2 MILES

SCALE

Figure 2.1-2
AREAS INVESTIGATED AS MIGRATION SOURCES ON RMA

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

Additional information examined in order to select potential areas of contamination came from the numerous documents on observed biological impacts associated with particular sites on RMA (U.S. Army Dugway Proving Ground, 1973, RIC#84131R02 and 1975a and b, RIC#84296R02 and 84296R03; U.S. Fish and Wildlife Service, 1965, RIC#84296R04 and 1982; Rosenlund et al. 1986, RIC#86041R02) and from documents containing information on contaminants in tissues from animals collected on and near RMA (Thorne, 1986a and b, RIC#86066R01 and 86091R02; U.S. Army Dugway Proving Ground 1975a and b, RIC#84296R02 and 84296R03). Information on the distribution of contaminants in biota at RMA are presented in Sections 2.3 and 2.4.

Presence in the physical environment at a particular site was not sufficient to designate a particular site as a potential contamination source for biota. In many instances contamination studies indicated that the chemical contamination was confined to underground aquifers, well below soil layers inhabited by most biota. In most cases, the precise distribution, concentration, and chemical composition of contaminants was not identified and the sites could not be completely eliminated from consideration.

Final determination of sites of contamination with respect to biota are being identified on the basis of information contained in the aforementioned documents produced by the U. S. Army Toxic and Hazardous Materials Agency (1983 and 1984, RIC#83326R01 and 84034R01), documents describing contaminant effects on biota which can be associated with a particular site or sites of contamination (e.g., lower lakes, Basin F, etc.), and documents summarizing data being collected at sites throughout RMA and the offpost study area (Figure 2.1-3). Data from current studies is presently being reviewed by the Army and will be used to update the list of sites of potential contamination to biota.

2.1.2 SITES OF CONTAMINATION

Present information from the current Phase I assessment studies is being compiled in a series of source reports for the various areas on and off RMA. Surveys conducted as a basis for these reports included surface water, ground water, and soil surveys throughout RMA and the offpost

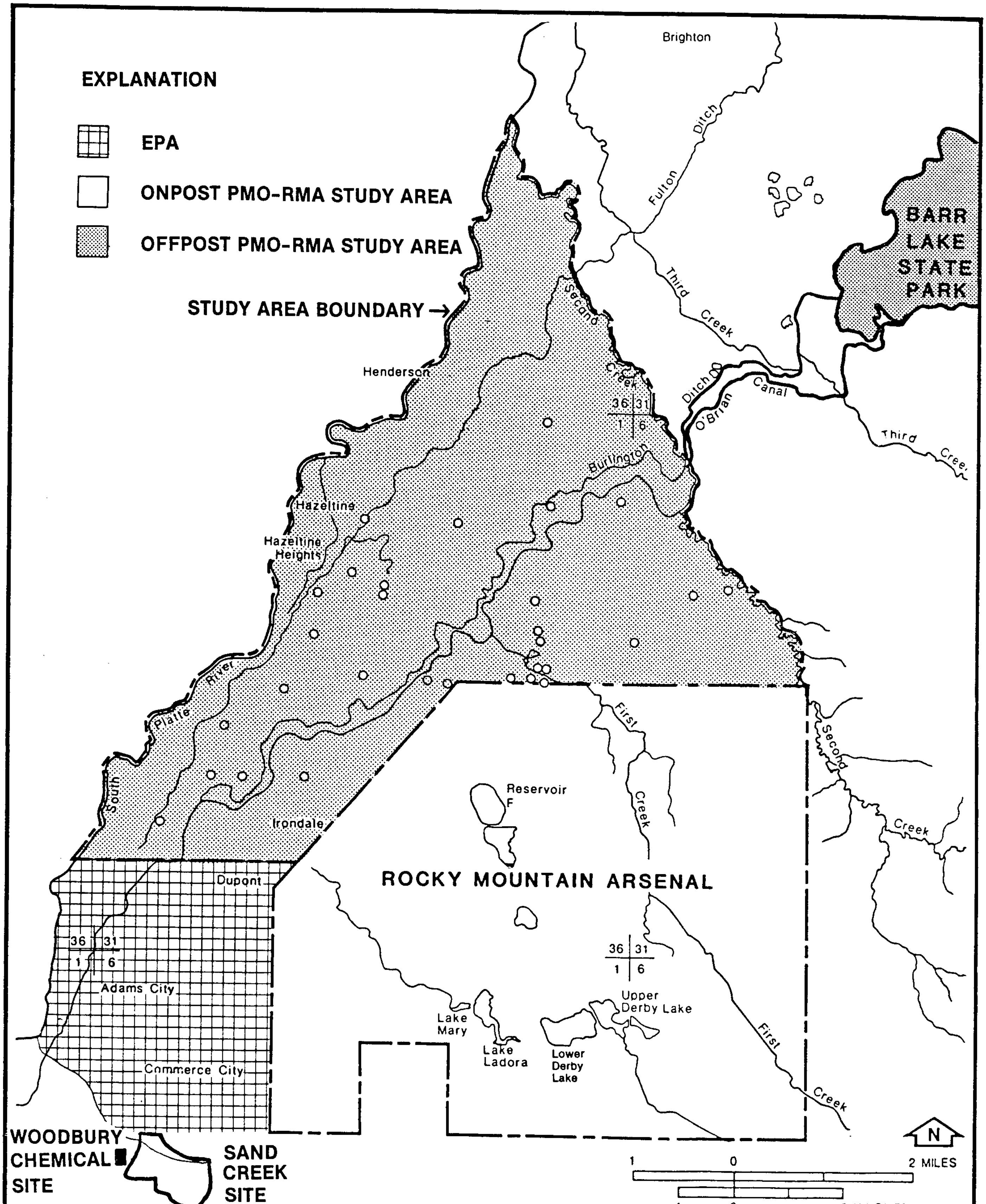


Figure 2.1-3
PHASE I STUDY AREA BOUNDARIES

SOURCE: ESE, 1984

Prepared for:
U.S. Army Program Manager's Office For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

study area. These surveys were conducted not only to determine the nature and extent of contamination at potential sites of contamination and contaminant migration, but also to determine if additional sites might exist. Preliminary indications suggest that the number of sites of concern may be smaller than the list of potential sites. These changes may be the result of incomplete or erroneous past documentation and/or the result of the dissipation of contamination over the past three decades. This would be particularly true of chemicals which can easily migrate through physical media or which are not persistent in the environment.

Assessment of contamination at RMA must therefore rely on documentation of past distribution of chemicals and effects on biota as well as a comprehensive knowledge of the present distribution of these chemicals in the environment. Because Phase I surveys of contaminants in surface water, ground water, and soil are not yet finished, it is not possible to determine all sites of contamination and sources of contaminant migration of RMA contaminants. However, major sites of contamination can be identified, based on information from a variety of sources (Thorne, 1986a and b, RIC#86066R01 and 86091R02; Torgeson and Sirois, 1976, RIC#81341R02; U.S. Army Environmental Hygiene Agency, 1973; Jensen, 1955, RIC#84292R04). The descriptions which follow include only major sites of contamination which have been identified in connection with known and potential effects on biota. Additional information from current Phase I investigations and future studies of contamination in biota will be incorporated into subsequent versions of this report.

2.1.2.1 South Plants Area and Basin A

In 1942, the Armed Forces of the United States had a critical need for chemical filled munitions, as well as an urgent requirement for incendiary munitions. Manufacture and filling of these munitions in the South Plants Area (Sections 1 and 2) resulted in discharge of liquid waste into the Basin A lime settling ponds and Basin A pool, located in Section 36, north of the South Plants Area. Other industrial operations in the area included the production, munition filling and storage of mustard gas, lewisite, phosgene, white phosphorous, chlorine, incendiary

mixtures, and explosive button bombs. Julius Hyman Company and Shell leased South Plants buildings for the manufacture of chlordane, DDT, dieldrin, aldrin, and other pesticides (PMCDIR, 1977, RIC#81266R68). Facilities completed in 1953 in the North Plants Area which produced GB agent also utilized Basin A for liquid waste disposal.

Historical and current data provide evidence which identifies the South Plants Area as containing the most heavily contaminated ground water on RMA. The following are representative of the problems known to have occurred in this area:

- A major spill of benzene in 1948. Benzene is currently present and migrating from the area;
- The surface disposal of waste in disposal ponds and burial pits;
- Spills of pesticides into the environment through surface ditches impacting Lower Lakes: Upper Derby, Lower Derby and Ladora;
- Plumes of contaminants with high migration potential indicated by ground water sampling and analysis;
- Infiltration and exfiltration of contaminants from sewers provide current active pathways for contaminant drainage from the source areas; and
- Buildings with contaminated water in basements and sumps.

Because of these problems, Basin A and the South Plants Area has contributed to past and current migration of contaminants in the direction of RMA boundaries.

2.1.2.2 <u>Lower Lakes</u>

The Lower Lakes consist of four water filled depressions. Lake Ladora is a natural lake clearly visible in its present configuration on 1937 aerial photographs. The remaining "lakes" are impoundments constructed in natural depressions following the creation of RMA and are interconnected by drainages. Lake Mary was completed in 1960. The Rod and Gun Club Pond was created by high water overflow from Lower Derby

Lake several years after the southern lakes were dredged (Geraghty and Miller, Inc., 1982, RIC#81342R06; USATHAMA, 1983, RIC#83326R01).

The lake system has been used as a source of process cooling water for the various industrial operations on RMA. Water was pumped from Lake Ladora via the pumping station, Building 371, and returned to Upper Derby Lake. The water flows by gravity into Lower Derby Lake and then to Lake Ladora. Lake Mary is not included as part of the process water system by any of the reviewed reports. There is no indication that waste was disposed of in Lake Ladora or Lake Mary. The lake system reportedly has received contaminants from the following:

- Recirculated process cooling water containing contaminants from defective equipment;
- Underground flow of contaminants from an acetylene waste disposal basin; and
- Shell operations in 1964 contributed pesticides, aldrin, and dieldrin contamination.

In 1964, Upper and Lower Derby Lakes and Lake Ladora were drained, and sediment was excavated. The sediment was placed in the north-central parts of Sections 11 and 12. Recovered sediments reported contained 25 to 50 ppm of dieldrin. Sediment samples were taken from Lake Ladora and Lake Mary as part of a 1983 study. Samples were analyzed for 81 priority contaminants. Chemicals that were above detection limits are mercury, aldrin, dieldrin, endrin, p,p-DDT, methylene chloride, diethylphthalate, phenanthrene, dibutylphthalate, and butylbenzylphthalate.

2.1.2.3 Basin F

The need for expanded waste storage facilities as a result of the manufacture of Agent GB from 1953 to 1957 resulted in the construction of Basin F. Basin F encompasses approximately 93 acres and was completed in 1957 with an asphalt-lined bottom protected with a 12 in thick sand overburden.

Problems associated with the storage of liquid wastes in Basin F were encountered early in its operation and were caused by wave action against the shoreline that, at the time, had not been protected by riprap. In 1957, tears in the asphalt liner were found. The Basin F contents were pumped into Basin C, an unlined facility, while repairs were made to the Basin F liner and riprap was installed.

Historical and current studies of Basin F have identified problems with the site. Parts of the liner which are torn are being exposed to the impounded liquid. Fluctuating liquid levels cause cyclical exposures of the liner to sunlight and weather conditions.

2.1.2.4 Basins C, D, E

Basin C, an unlined evaporation pond, stored overflow from Basins A and B, large quantities of freshwater from Sand Creek Lateral, and temporarily held approximately 100 million gallons of liquid wastes while Basin F underwent lining repairs in 1957. Basins D and E, also unlined, received overflow from Basin A from 1953 until the construction of Basin F in 1956. These four basins overlie several contamination plumes originating in the Basin A area, making it difficult to assess whether they are true sources. Chemical analyses of soil samples from the basins found traces of DIMP, PCPMS, PCPMSO, and $PCPMSO_2$ in solvent extracts. Water extracts of soil samples resulted in below detectable limits for all parameters except PCPMSO.

2.1.2.5 North Bog

A small body of surface water called North Bog is located on the northern boundary of RMA in Section 24 (Figure 1.1-2). This pond receives surface water from the North Boundary System and is believed to have a subsurface connection with shallow aquifers which may be contaminated. Several species of ducks from this pond show levels of contamination in their tissue (see Section 4.0) which may have come from surface water or sediments in this pond. Surface water testing is planned and sediment testing is contemplated for the summer of 1986 which would provide data necessary for implicating North Bog as a source of contamination of concern to biota.

2.1.2.6 Offpost Biota

Domesticated Crops and Animals

Damage to domesticated biota in the area adjacent to RMA was first documented in the summer of 1954 when several farmers complained that ground water used for irrigation had damaged their crops (USATHAMA, 1984, RIC#84034R01). In May 1974, two compounds directly related to operations at RMA were detected in surface water drainage from a man-made pond on the northern boundary of RMA.

Offsite contaminant migration in the early-1970's prompted the Colorado Department of Health to issue a series of administrative orders that led to the establishment of the Contamination Control Program by the U.S. Army. Several pollution abatement efforts have been implemented since that time however, contaminants are still present in shallow aquifer and some surface water areas within the offpost study area (Figure 2.1-3).

Offpost investigations on the types, concentrations, and distribution of ground water plumes are presently being performed. Data developed from these studies will be available in the near future which can be used to determine potential for contamination of domestic biota in the offpost study area.

Offpost Ecosystems

Potential exists for the migration of RMA contaminants into natural ecosystems in the offpost study area. Ground water distribution to surface water along the O'Brian Canal could lead to the contamination of surface waters and sediments in the canal and in Barr Lake (Figure 2.1-3). Sediment and surface water sampling in the canal and at Barr Lake will be conducted on a quarterly basis. Results of these studies can be used to evaluate the potential for contamination of biological resources in these areas (see Section 5.0 for evaluation methods).

2.2 CONTAMINANTS OF POTENTIAL CONCERN

A list of potential contaminants of concern to biota was derived by first listing all compounds found in biota (compiled through a review of all notes and literature on RMA biological studies). The initial list also included compounds included in current ground water and/or soil screening programs, and compounds known to be associated with operations at RMA (Geraghty & Miller, 1986, RIC#86107R01). For each potential contaminant categories of information were added to form a matrix of available data for each compound. Compounds finally listed as "Potential Contaminants" were those found in biota sampled at RMA, and/or those which satisfied the following criteria:

1. Present in RMA environment above ambient concentrations. Many chemicals were not included in tests during RMA environmental screening processes, and records did not indicate that these had contaminated the environment. There was therefore no evidence that these chemicals occur in the RMA environment. This group includes chemical used in laboratory or production processes, or which are intermediate or degradation products of these processes (Geraghty & Miller, 1986, RIC#86107R01);
2. Rated at least "Moderately Toxic" by Geraghty and Miller (1986) based on information from the Merck Index. With two exceptions, only compounds rated "Moderately Toxic" or "Severely Toxic" were included for consideration; and
3. Volume of disposal and/or persistence data. Information on volume of disposal and/or persistence (half-life) (Geraghty and Miller, 1986, RIC#86107R01) was considered important because it provided some indication of the potential occurrence of the chemicals presently at RMA. Chemicals of low disposal volume and low persistence may be more difficult to detect or sample than chemicals of high disposal volume and/or moderate volume and high persistence.

DMMP was included because it is associated with DIMP, and because it was disposed of in relatively high volumes. Methylphosphonic acid (MPA), though of low toxicity, was included because it is toxic to plants, mobile in ground water, and highly persistent in the environment (Geraghty & Miller, 1986, RIC#86107R01).

The list of potential contaminants of concern that resulted from the above matrix construction is shown in Table 2.2-1. The third criterion was applied to the extent possible, based on the variability in available information on volume, toxicity, and other pertinent data. The list of chemicals is subject to periodic updating as a result of new information generated from the remedial investigation and related studies.

Various Contamination Assessment Reports (CAR) completed for the South Plants (Task 2) and the Lower Lakes (Task 7) by EBASCO in March 1986, and by ESE in February 1986 for sites in Section 36 (Task 1) indicate that fewer chemicals than previously thought have been detected in the RMA environment. As they become available, these CAR's will be used to update or refine biota contaminant studies.

2.3 CONTAMINANTS IN BIOTA

Observations of contaminants in and contaminant effects on biota have been documented by various agencies and personnel on RMA for more than three decades. These studies have been undertaken both as response actions to specific incidents and as monitoring activities at selected sites of known contamination. Examination of data from these investigations indicates that some effects on biota may have resulted from specific spills, but that others have resulted from persistent contamination problems in diverse species throughout this time period.

Although numerous studies relating contaminants in the physical environment to contaminant levels in selected species of biota have been conducted, quantitative data are generally lacking. In addition, each study that involved analysis for a particular suite of chemicals, was usually associated with a particular site or group of sites, and most were conducted at different times over a span of 30 years. Because

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Page 1 of 3)

	Found In Biota Sampled at RMA	In RMA Environment	On "Potential for Migration" List	On Soil "Hit List"	Volume	Persistence (Half-life)	Toxicity
Aldrin	X	X	X	X	M,S	H	H*
Allyl chloride		X		X	L,S	L	H*
Arsenic	X	X	X	X	-	H	H*
Atrazine		X	-	X	-	M	M*
Azodrin		X		X	M,S	L	M*
Cadmium	X	X	X	X	-	-	H*
Chlordane	X	X	-	X	-	H	H*
p-cpm sulfide	X	X	X	X	M	M	M-L
p-cpm sulfone	X	X	X	X	M	H	H-M
p-cpm sulfoxide	X	X	X	X	L	H	M
Chlorobenzene		X	X	X	-	M	M-L
Chloroform		X	X	X	H	H	H*
Copper	X	X	X	X	-	H	H
Dibromochloropropane (DBCP)	X	X	X	X	M,S	M	H*
p,p[1] - DDT	X	X	X	X	-	H	H*
p,p[1] - DDE	X	X	X	X	-	H	M-L
Dicyclopentadiene (DCPD)		X	X	X	HP,M,S	M	H-M
Dieldrin	X	X	X	X	HP,H	H	H*
DIMP	X	X	X	X	MP	H	M-L
DMMP			X	X	H	-	L
Dithiane	X	X	X	X	-	-	M-L
Endrin	X	X	X	X	M	H	H*
Ethylbenzene		X	X	X	-	L	M-L*
Heptachlor		X				H	H*
Heptachlorepoxide (HE)	X	X				H	H*
Isodrin	X	X	X	X	M	H	H
Malathion		X		X	-	-	H*
Mercury	X	X	X	X	S	H	H

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Continued, Page 2 of 3)

	Found In Biota Sampled at RMA	In RMA Environment	On "Potential for Migration" List	On Soil "Hit List"	Volume	Persistence (Half-life)	Toxicity
Methyl parathion		X		X	M	L	H-M*
Methylphosphonic Acid		X		X	M	H	L
Mustard		X		X	NR	H	H*
Nitrosodimethylamine		X		X	-	-	H*
1,4-Oxathiane	X	X	X	X	-	-	M
Oxychlordane	X					H	-
Parathion	X	X		X	-	-	H*
PCB	X	-	-	-	-	H	-
Toluene		X	X	X	H,S	M	H*
Trichloroethylene		X	X	X	-	H	H*
Xylene		X	X	X	M,S	L	M*

*Volume

H =High waste disposal
M = Moderate waste disposal
L = Low waste disposal
S = Spills, volume not rated

HP =High production
MP = Moderate production
LP = Low production
NR = Not able to rate

volume < 48,049 lbs. = Low production volume

48,049 $\leq$ volume $\leq$ 396,850 lbs. = Moderate production volume

volume > 396,850 lbs. = High production volume

volume < 45,000 lbs. = Low disposal volume

45,000 $\leq$ volume $\leq$ 720,000 = Moderate disposal volume

volume > 720,000 = High disposal volume

Table 2.2-1. Matrix of Criteria Used to Determine Potential Contaminants* (Continued, Page 3 of 3)

Persistence/Half Life Data

H =High persistence
M = Moderate persistence
L = Low persistence

half-life $<$ 60 days = Low persistence

60 $\leq$ half-life $\leq$ 365 days = Moderate persistence

half-life $<$ 365 days = High persistence

Toxicity Rating

Toxicity Rating for chemicals on the core lists are from these sources:

1. Sax, N. Irving, 1984. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company.

2. Rosenblatt, David H., 1985, April 25. HCIC Report: Literature reviews on 13 RMA on-post contaminants. 1985, May 2. Literature reviews on 12 RMA on-post contaminants.

3. The Merck Index, 1983, Tenth Edition, Merck and Company, Inc.

H = Severely toxic
M = Moderately toxic
L = Slightly toxic
NR = No toxicity rating assigned
* = Toxic Hazard Review availabe in Chemical Index

all potential contaminants have not been systematically surveyed in biota, a completely quantitative evaluation of contaminants in biota and potential contaminant effects based on existing information is not possible at this time. Some of the incidences which have occurred in the past have been followed by cleanup measures, hence quantification of injury to biota must rely on data collected in the past as current studies are not possible in these instances.

An assessment of contamination in biota involves two types of information. The contaminant levels in different species of biota must be documented at levels above regional background, and these levels must be associated with demonstrated effects. Information on contaminant levels observed in species from RMA and observations of contaminant effects associated with these chemicals are provided below.

2.3.1 CONTAMINATION LEVELS IN BIOTA

Most data indicating contamination in the tissues of plants and animals at RMA are associated with identified major sources of known or potential contamination. These sources have been identified and discussed in Section 2.1 and the chemicals of potential concern have been considered in Section 2.2. Tables 2.3-1 through 2.3-5 summarize existing information on species of biota at RMA in which chemical contamination has been documented during the past three decades. Due to the quantity of existing information, ranges of contamination in species are presented and reference is made to pertinent documents as sources of additional information.

Examination of these tables shows that a variety of key wildlife species contain RMA contaminants. Plant tissues have not been examined as thoroughly, but evidence of adverse effects has also been noted. In spite of the fact that a comprehensive survey has not been conducted, these studies which were conducted over a period of more than thirty years demonstrate that a wide range of species in aquatic, wetland, and terrestrial ecosystems contain or contained contaminants with known adverse effects on biota. The distribution of these contaminants in

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Page 1 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Algae	Aldrin	3.0 - 73.0 ppm	RZA 001 2217, RFA 003 0659-0661, RFA 003 1262F
02	Algae	Aldrin	1.2 ppm	RFA 003 0659-0661
01	Blue-Winged Teal	Aldrin	0.1 - 0.17 ppm	RMA 046 2040
01	Mallard	Aldrin	0.03 - 0.20 ppm	RMA 162 0821F, RMA 045 1751, RMA 046 2040
01	Aquatic snails	Aldrin	9.0 -38.0 ppm	RFA 003 0659-0661
01	Redhead	Aldrin	1.0 ppm	RFA 003 0659-0661
01	Black Bullhead	Aldrin	0.03 - 0.28 ppm	RMA 045 1786
02	Black Bullhead	Aldrin	0.01 ppm	RFA 001 0338
02	Leech	Aldrin	0.1 ppm	RIC#84296R04
02	Bluegill	Aldrin	0.01 ppm	RFA 001 0338
01	Largemouth Bass	Aldrin	0.03 ppm	RMA 045 1786, RIC#84296R02
02	Largemouth Bass	Aldrin	0.08 - 0.1 ppm	RMA 045 1786, RIC#84296R02
02	Rainbow Trout	Aldrin	0.18 ppm	RMA 036 1575
02	Mourning Dove	Aldrin	0.05 ppm	RMA046 2040
02	Largemouth Bass	Arsenic	2.0 - 2.20 ppm	RMA045 1786
02	Shoveler	Chlordane	15.0 ppm	RSH 855 1544F
02	Mallard	Chlordane	4.8 - 20.0 ppm	RSH 855 1544F
02	Mallard	CPM Sulfoxide	0.25 - 0.26 ppm	RMA 045 1797
02	Mallard	CPM Sulfide	0.04 ppm	RMA 045 1797
02	Mourning Dove	CPM Sulfone	0.22 ppm	RMA 045 1751F
01	Mallard	Copper	16.8 - 31.5 ppm	RMA 162 0821F
02	Mallard	Copper	8.6 - 9.4 ppm	RMA 162 0821F
01	Blue-Winged Teal	DBCP	0.36 ppm	RMA 046 2040
01	Mallard	DBCP	0.03 - 0.51 ppm	RMA 046 2040
01	Algae	Dieldrin	2.7 - 45.0 ppm	RFA 003 0659-0661, RFA 003 1262F
02	Algae	Dieldrin	23.0 - 39.0 ppm	RFA 003 0659-0661, RFA 003 1262F
01	Tiger Salamander	Dieldrin	117.0 ppm	RFA 003 0659-0661
01	Northern Pintail	Dieldrin	5.0 - 36.0 ppm	RFA 003 0659-0661, RFA 003 1262F
02	Northern Pintail	Dieldrin	5.0 - 36.0 ppm	RSH 855 1544F
02	Shoveler	Dieldrin	10.0 - 44.0 ppm	RZA 001 2217, RFA 003 0659-0661, RSH 855 1544F
02	Green-Winged Teal	Dieldrin	9.0 - 58.0 ppm	RZA 001 2217, RFA 003 0659-0661, RSH 855 1544F
01	Blue-Winged Teal	Dieldrin	0.12 - 39.0 ppm	RFA 003 0659-0661, RMA 046 2040, RMA 045 1797
02	Blue-Winged Teal	Dieldrin	39.0 ppm	RSH 855 1544F
01	Mallard	Dieldrin	0.52 - 48.0 ppm	RFA 003 0659-0661, RMA 046 2040, RMA 162 0821F, RMA 045 1751F
02	Mallard	Dieldrin	0.08 - 81.0 ppm	RMA 162 0821F, RMA 045 1751F, RDA 002 1865, RMA 031 0751F

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 2 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Gadwall	Dieldrin	3.4 ppm	RFA 003 1262F
01	Aquatic snails	Dieldrin	32.0 - 77.0 ppm	
02	Aquatic snails	Dieldrin	22.0 - 28.0 ppm	RSH 855 1544F
01	Redhead	Dieldrin	12.0 ppm	RFA 003 0659-0661
02	Redhead	Dieldrin	10.0 ppm	RFA 003 0659-0661
01	Ring-Necked Duck	Dieldrin	4.0 ppm	RFA 003 0659-0661
01	Canada Goose	Dieldrin	2.1 - 3.0 ppm	RSH 855 1544F
02	Goldeneye	Dieldrin	8.8 ppm	RSH 855 1544F
01	Northern Pike	Dieldrin	0.03 - 0.12 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01 RMA 117 1364-1374, RMA 045 1769F
02	Northern Pike	Dieldrin	0.03 - 0.12 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	American Coot	Dieldrin	1.43 - 5.0 ppm	RSH 855 1544F, RDA 002 1865
02	Channel Catfish	Dieldrin	0.16 ppm - 0.22 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	Dieldrin	0.05 ppm - 0.44 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	Dieldrin	0.03 - 0.40 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Leech	Dieldrin	83.0 ppm	RSH 855 1544F
02	Bluegill	Dieldrin	0.03 - 3.05 ppm	RFA 001 0338, RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Common Merganser	Dieldrin	6.6 ppm	RSH 855 1544F
02	Common Merganser	Dieldrin	6.6 - 14.0 ppm	RSH 855 1544F
01	Largemouth Bass	Dieldrin	0.03 - 0.46 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	Dieldrin	0.03 - 3.94 ppm	RFA 001 0338, RMA 045 1786, RIC#84296R03, RMA 031 0751F, RIC#85115R01, RMA 045 1769F
01	Pheasant	Dieldrin	0.04 - 0.16 ppm	RMA 045 1751F
02	Pheasant	Dieldrin	0.04 - 14.4 ppm	RSH 855 1544F, RMA 045 1797
02	Rainbow Trout	Dieldrin	2.0 ppm	RMA 036 1575
01	Desert Cottontail	Dieldrin	0.03 - 0.59 ppm	RMA 045 1751F, RMA 045 1797, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	American Robin	Dieldrin	2.3 ppm	RZA 001 2217
02	Cattails	Dieldrin	5.0 ppm	RFA 003 0659-0661
02	Mourning Dove	Dieldrin	0.03 - 0.61 ppm	RMA 046 2040, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
01	Blue-Winged Teal	Endrin	0.1 - 0.11 ppm	RMA 046 2040
01	Mallard	Endrin	0.04 - 0.18 ppm	RMA 046 2040, RMA 045 1751F
02	Mallard	Endrin	0.03 - 0.24 ppm	RMA 162 0821F, RMA 045 1751F
01	Northern Pike	Endrin	0.03 - 0.04 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Channel Catfish	Endrin	0.03 ppm	RMA 031 0751F
01	Black Bullhead	Endrin	0.03 - 0.14 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 3 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
02	Black Bullhead	Endrin	0.03 ppm	RMA 045 1786, RMA 031 0751F
01	Northern Bluegill	Endrin	0.03 ppm	RMA 045 1786
01	Largemouth Bass	Endrin	0.03 - 0.04 ppm	RMA 045 1786, RMA 031 0751F
01	Aquatic snails	Endrin	1.41 ppm	RMA 076 0736
02	Aquatic snails	Endrin	1.41 ppm	RMA 076 0736
02	Rainbow Trout	Endrin	0.29 ppm	RMA 036 1575
02	Mourning Dove	Endrin	0.03 - 0.42 ppm	RMA 046 2040, RMA 045 1751F
02	Rainbow Trout	Heptachlor epoxide	0.01 ppm	RMA 036 1575
01	Mallard	Isodrin	0.13 ppm	RMA 162 0821F
01	Black Bullhead	Isodrin	0.02 - 0.03 ppm	RMA 045 1786
02	Mourning Dove	Isodrin	0.13 - 0.16 ppm	RMA 046 2040
01	Blue-Winged Teal	Mercury	2.1 - 5.3 ppm	RMA 046 2040
01	Mallard	Mercury	0.29 - 3.8	RMA 046 2040
01	Northern Pike	Mercury	0.28 - 1.60 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Northern Pike	Mercury	0.21 - 4.5 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Channel Catfish	Mercury	0.35 - 0.50 ppm	RMA 045 1786, RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	Mercury	0.16 - 9.0 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	Mercury	0.20 - 0.94 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	Northern Bluegill	Mercury	0.36 ppm	RMA 045 1786
02	Northern Bluegill	Mercury	0.14 - 1.80 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
01	Largemouth Bass	Mercury	0.40 - 0.44 ppm	RMA 045 1786, RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	Mercury	0.19 - 15.3 ppm	RMA 045 1786, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
01	Pheasant	Mercury	0.23 - 1.2 ppm	RMA 045 1751F
01	Desert Cottontail	Mercury	0.2 ppm	RMA 045 1751F
02	Shoveler	P,p-DDE	0.1 ppm-1.8 ppm	RSH 855 1544F
01	Blue-Winged Teal	P,p-DDE	0.07 ppm	RMA 046 2040
01	Mallard	P,p-DDE	0.23 - 0.47 ppm	RMA 162 0821F
02	Mallard	P,p-DDE	0.1 - 0.39 ppm	RMA 162 0821F, RMA 045 1751F
02	Aquatic snails	P,p-DDE	1.0 ppm	RSH 855 1544F
01	Canada Goose	P,p-DDE	0.04 - 7.0 ppm	RSH 855 1544F
02	Goldeneye	P,p-DDE	1.4 ppm	RSH 855 1544F
01	Northern Pike	P,p-DDE	0.03 - 0.21 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Northern Pike	P,p-DDE	0.03 - 0.14 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374 RMA 045 1769F
02	Channel Catfish	P,p-DDE	0.05 - 0.09 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374

Table 2.3-1. Contaminants Recorded From Biota From the Lower Lakes (Lake Mary, Lake Ladora, Lower Derby, and Upper Derby) (Continued, Page 4 of 4)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
01	Black Bullhead	P,p-DDE	0.03 - 0.12 ppm	RMA 045 1786, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Black Bullhead	P,p-DDE	0.03 - 0.43 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374, RMA 045 1769F
02	Leech	P,p-DDE	4.5 ppm	RSH 855 1544F
01	Northern Bluegill	P,p-DDE	0.37 ppm	RMA 045 1786
02	Northern Bluegill	P,p-DDE	0.03 - 0.10 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01
01	Common Merganser	P,p-DDE	1.4 ppm	RSH 855 1544F
02	Common Merganser	P,p-DDE	1.3 ppm	RSH 855 1544F
01	Largemouth Bass	P,p-DDE	0.05 - 0.08 ppm	RMA 031 0751F, RMA 045 1769F
02	Largemouth Bass	P,p-DDE	0.03 - 0.30 ppm	RFA 001 0338, RMA 162 0821F
02	Pheasant	P,p-DDE	0.03 - 1.4 ppm	RSH 855 1544F, RMA 045 1797
02	Rainbow Trout	P,p-DDE	0.23 ppm	RMA 036 1575
02	Mourning Dove	P,p-DDE	0.02 - 0.53 ppm	RMA 046 2040, RIC#85115R01, RMA 117 1364-1374
01	Blue-Winged Teal	P,p-DDT	0.19 ppm	RMA 046 2040
01	Mallard	P,p-DDT	0.02 - 0.96 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
02	Mallard	P,p-DDT	0.03 - 0.10 ppm	RMA 162 0821F, RMA 045 1751F
02	Aquatic snails	P,p-DDT	0.1 ppm	RIC#84296R04
01	Northern Pike	P,p-DDT	0.04 - 0.09 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Northern Pike	P,p-DDT	0.03 - 0.09 ppm	RIC#85115R01, RMA 117 1364-1374
01	Black Bullhead	P,p-DDT	0.02 - 0.04 ppm	RMA 045 1786
02	Black Bullhead	P,p-DDT	0.03 - 0.11 ppm	RFA 001 0338, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
02	Leech	P,p-DDT	0.7 ppm	RIC#84296R04
02	Northern Bluegill	P,p-DDT	0.01 - 0.03 ppm	RFA 001 0338, RIC#85115R01, RMA 117 1364-1374
01	Largemouth Bass	P,p-DDT	0.07 - 0.1 ppm	RMA 045 1786, RMA 031 0751F
02	Largemouth Bass	P,p-DDT	0.02 - 0.09 ppm	RMA 031 0751F
02	Mourning Dove	P,p-DDT	0.08 ppm	RMA 046 2040
02	Rainbow Trout	Parathion	0.30 ppm	

Table 2.3-2. Contaminants Recorded From Biota in Section 36 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Prairie Dog	Oxathiane	0.12 ppm	RMA 076 0736
Earthworms	Aldrin	0.02 ppm	RMA 076 0736
Grasshoppers	Aldrin	0.705 ppm	RMA 076 0736
Earthworms	Cadmium	3.63 ppm	RMA 076 0736
Prairie Dog	CPM Sulfone	0.12 - 0.22 ppm	RMA 076 0736
Grasshoppers	CPM Sulfone	0.11 - 0.95 ppm	RMA 076 0736
Grasshoppers	CPM Sulfoxide	0.27 - 1.11 ppm	RMA 076 0736
Prairie Dog	Copper	8.50 ppm	RMA 076 0736
Earthworms	Copper	46.0 ppm	RMA 076 0736
Grasshoppers	Copper	17.6 ppm	RMA 076 0736
Deer Mouse	Copper	5.30 ppm	RMA 076 0736
Pheasant	Copper	8.10 ppm	RMA 076 0736
Western Meadowlark	Copper	25.3 ppm	RMA 076 0736
Desert Cottontail	Copper	14.1 ppm	RMA 076 0736
Mourning Dove	Copper	6.3 ppm	RMA 076 0736
Prairie Dog	Dieldrin	0.04 - 0.57 ppm	RMA 076 0736
Earthworms	Dieldrin	6.57 ppm	RMA 076 0736
Grasshoppers	Dieldrin	0.078 - 1.38 ppm	RMA 076 0736
Deer Mouse	Dieldrin	0.02 - 0.49 ppm	RMA 076 0736
Pheasant	Dieldrin	0.2 ppm	RMA 076 0736
Western Meadowlark	Dieldrin	0.99 ppm	RMA 076 0736
Desert Cottontail	Dieldrin	0.21 ppm	RMA 076 0736
Mourning Dove	Dieldrin	0.53 - 1.81 ppm	RMA 076 0736, RMA 045 1797

Table 2.3-2. Contaminants Recorded From Biota in Section 36 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Prairie Dog	DIMP	0.20 - 1.52 ppm	RMA 076 0736
Grasshoppers	DIMP	0.17 - 0.71 ppm	RMA 076 0736
Deer Mouse	DIMP	0.06 - 0.09 ppm	RMA 076 0736
Prairie Dog	Dithiane	0.13 ppm	RMA 076 0736
Earthworms	Endrin	0.76 ppm	RMA 076 0736
Pheasant	Endrin	0.37 ppm	RMA 076 0736
Mourning Dove	Endrin	0.03 - 0.05 ppm	RMA 045 1797
Earthworms	Isodrin	0.02 ppm	RMA 076 0736
Grasshoppers	Isodrin	0.167 ppm	RMA 076 0736
Pheasant	Mercury	0.2 ppm	RMA 076 0736
Western Meadowlark	Mercury	0.33 ppm	RMA 076 0736
Prairie Dog	P,p-DDE	0.02 - 0.13 ppm	RMA 076 0736
Grasshoppers	P,p-DDE	0.021 - 0.03 ppm	RMA 076 0736
Deer Mouse	P,p-DDE	0.02 - 0.05 ppm	RMA 076 0736
Pheasant	P,p-DDE	0.22 ppm	RMA 076 0736
Mourning Dove	P,p-DDE	0.04 ppm	RMA 076 0736
Earthworms	P,p-DDT	0.18 ppm	RMA 076 0736
Pheasant	P,p-DDT	0.11 ppm	RMA 076 0736
Mourning Dove	P,p-DDT	0.05 ppm	RMA 045 1797

Table 2.3-3. Contaminants From Biota in Section 24 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Mallard	Oxathiane	0.20 ppm	RMA 045 1797
Aquatic snails	Oxathiane	0.36 ppm	RMA 076 0736
Mallard	Aldrin	0.02 ppm	RMA 045 1751F
Aquatic snails	Aldrin	0.03 - 0.33 ppm	RMA 076 0736
Mourning Dove	Aldrin	0.04 - 0.05 ppm	RMA 046 2040
Earthworms	Cadmium	2.45 ppm	RMA 076 0736
Mallard	CPM Sulfoxide	0.20 - 0.24 ppm	RMA 045 1797
Mourning Dove	CPM Sulfide	0.2 ppm	RMA 046 2040
Aquatic snails	Copper	13.4 ppm	RMA 076 0736
Earthworms	Copper	2.6 ppm	RMA 076 0736
Deer Mouse	Copper	5.50 ppm	RMA 076 0736
Pheasant	Copper	12.9 ppm	RMA 076 0736
Meadowlark	Copper	25.9 ppm	RMA 076 0736
Mourning Dove	Copper	18.5 ppm	RMA 076 0736
Canadian Thistle	Copper	3.0 - 120.0 ppm	RMA 037 0170-0185
Musk Thistle	Copper	5.0 - 9.0 ppm	RMA 037 0170-0185
Cheatgrass	Copper	5.0 - 8.0 ppm	RMA 037 0170-0185
Pheasant	DBCP	0.03 ppm	RMA 046 2040
Cheatgrass	Dieldrin	0.06 ppm	RMA 037 0170-0185
Kochia	Dieldrin	0.09 ppm	RMA 037 0170-0185
Blue-Winged Teal	Dieldrin	0.16 ppm	RMA 031 0751F
Mallard	Dieldrin	0.08 - 3.58 ppm	RMA 046 2040, RMA 045 1751F, RMA 045 1797, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	Dieldrin	2.2 - 3.9 ppm	RMA 076 0736
Earthworms	Dieldrin	1.27 ppm	RMA 076 0736
Deer Mouse	Dieldrin	0.08 ppm	RMA 076 0736
Pheasant	Dieldrin	0.04 - 0.15 ppm	RMA 076 0736, RMA 046 2040, RMA 045 1797
Meadowlark	Dieldrin	0.05 ppm	RMA 076 0736
Mourning Dove	Dieldrin	0.02 - 1.23 ppm	RMA 076 0736, RMA 046 2040, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	DIMP	0.19 ppm	RMA 076 0736
Cheatgrass	DIMP	0.12 - 6.01 ppm	RMA 037 0170-0185
Musk thistle	DIMP	0.35 ppm	RMA 037 0170-0185
Canadian thistle	DIMP	0.32 ppm	RMA 037 0170-0185
Kochia	DIMP	0.29 - 12.11	RMA 037 0170-0185
Mallard	Endrin	0.02 - 0.07 ppm	RMA 046 2040, RMA 045 1751F RMA 031 0751F

Table 2.3-3. Contaminants From Biota in Section 24 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppm (parts per million)	Reference
Aquatic snails	Endrin	2.34 ppm	RMA 076 0736
Earthworms	Endrin	0.84 ppm	RMA 076 0736
Mourning Dove	Endrin	0.03 - 0.1 ppm	RMA 076 0736
Cheatgrass	Endrin	0.04 ppm	RMA 037 0170-0185
Aquatic snails	Isodrin	0.05 ppm	RMA 076 0736
Mourning Dove	Isodrin	0.14 ppm	RMA 046 2040
Mallard	Mercury	0.29 - 2.40 ppm	RMA 046 2040, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Pheasant	Mercury	0.26 - 0.38 ppm	RMA 076 0736, RMA 045 1751F
Meadowlark	Mercury	0.37 ppm	RMA 076 0736
Musk thistle	Mercury	0.25 - 0.42 ppm	RMA 037 0170-0185
Mallard	p,p`-DDE	0.09 - 0.16 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Aquatic snails	p,p`-DDE	0.16 ppm	RMA 076 0736
Earthworms	p,p`-DDE	0.15 ppm	RMA 076 0736
Deer Mouse	p,p`-DDE	0.05 ppm	RMA 076 0736
Pheasant	p,p`-DDE	0.04 ppm	RMA 076 0736
Meadowlark	p,p`-DDE	0.04 ppm	RMA 076 0736
Mourning Dove	p,p`-DDE	0.03 - 0.15 ppm	RMA 076 0736, RMA 046 2040
Canadian thistle	p,p`-DDE	0.17 - 0.22 ppm	RMA 037 0170-0185
Mallard	p,p`-DDT	0.02 - 0.03 ppm	RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDT	0.07 ppm	RMA 045 1797

Addendum: Contaminants Recorded from Biota from the North Bog in Section 24

Mallard	Dieldrin	0.09 ppm (edible portion)	RIC#86091R02
	Dieldrin	1.00 ppm (liver)	RIC#86091R02
	DIMP	0.06 ppm (liver)	RIC#86091R02
	Endrin	0.07 ppm (liver)	RIC#86091R02
	p,p`-DDE	0.40 ppm (edible portion)	RIC#86091R02
	p,p`-DDT	0.08 ppm (liver)	RIC#86091R02
	1,4-Oxathiane	0.22 ppm (liver)	RIC#86091R02
Blue-Winged Teal	Dieldrin	0.46 ppm (edible portion)	RIC#86091R02
	Dieldrin	3.3 ppm (liver)	RIC#86091R02
	p,p`-DDE	0.3 ppm (edible portion)	RIC#86091R02
	p,p`-DDE	0.08 ppm (liver)	RIC#86091R02
	Endrin	0.22 ppm (liver)	RIC#86091R02
	1,4-Oxathiane	0.30 ppm (liver)	RIC#86091R02

Table 2.3-4. Contaminants Recorded From Biota in Section 26 (Page 1 of 2)

Species Represented	Contaminants	Amount Range ppb (parts per billion) ppm (parts per million)	Reference
Northern Pintail	Aldrin	0.06 ppb	RDA 002 1865
Mallard	Aldrin	5 ppb	RDA 002 1865
Earthworms	Aldrin	0.03 ppm	RMA 076 0736
Grasshoppers	Aldrin	0.169 - 0.39 ppm	RMA 076 0736
Plains Spadefoot	Aldrin	3-100 ppb	RDA 002 1865
Cheatgrass	Aldrin	0.5 - 0.13 ppm	RMA 037 0170-0185
Rush Skelton weed	Aldrin	0.14 ppm	RMA 037 0170-0185
Earthworms	Cadmium	2.57 ppm	RMA 076 0736
Cheatgrass	Cadmium	1.0 ppm	RMA 037 0170-0185
Prickly lettuce	Cadmium	1.0 ppm	RMA 037 0170-0185
Grasshoppers	CPM Sulfoxide	0.36 - 0.51 ppm	RMA 076 0736
Cheatgrass	CPM Sulfoxide	2.07 - 4.78 ppm	RMA 037 0170-0185
Rush Skelton weed	CPM Sulfoxide	1.48 - 19.5 ppm	RMA 037 0170-0185
Kochia	CPM Sulfoxide	6.00 - 12.12 ppm	RMA 037 0170-0185
Pheasant	CPM Sulfone	0.36 - 1.9 ppm	RMA 046 2040, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Desert Cottontail	CPM Sulfone	0.27 - 0.46 ppm	RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Mourning Dove	CPM Sulfone	0.53 - 2.53 ppm	RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Prickly lettuce	CPM Sulfide	2.62 ppm	RMA 037 0170-0185
Prickly lettuce	Copper	5.0 - 9.4 ppm	RMA 037 0170-0185
Prairie Dog	Copper	5.40 ppm	RMA 076 0736
Earthworms	Copper	31.0 ppm	RMA 076 0736
Grasshoppers	Copper	7.1 - 37.6 ppm	RMA 076 0736
Deer Mouse	Copper	6.8 ppm	RMA 076 0736
Pheasant	Copper	5.70 ppm	RMA 076 0736
Western Meadowlark	Copper	29.8 ppm	RMA 076 0736
Desert Cottontail	Copper	13.5 ppm	RMA 076 0736
Mourning Dove	Copper	14.2 ppm	RMA 076 0736
Cheat grass	Copper	5.8 - 15.0 ppm	RMA 037 0170-0185
Kochia	Copper	8.0 - 9.0 ppm	RMA 037 0170-0185
Northern Pintail	Dieldrin	1.3 ppm	RDA 002 1865
Shoveler	Dieldrin	340 ppb	RDA 002 1865
Mallard	Dieldrin	900 ppb	RMA 045 1751F, RSH 855 1544F, RDA 002 1865
		0.11 - 0.84 ppm	RMA 045 1751F, RDA 002 1865, RMA 117 1364-1374

Table 2.3-4. Contaminants Recorded From Biota in Section 26 (Continued, Page 2 of 2)

Species Represented	Contaminants	Amount Range ppb (parts per billion) ppm (parts per million)	Reference
Earthworms	Dieldrin	7.0 ppm	RMA 076 0736
Grasshoppers	Dieldrin	0.54 - 5.38 ppm	RMA 076 0736
Deer Mouse	Dieldrin	4.10 ppm	RMA 076 0736
Pheasant	Dieldrin	0.02 - 2.83 ppm	RMA 046 2040, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Plains Spadefoot	Dieldrin	300-875 ppb	RDA 002 1865
		2.7 ppm	RDA 002 1865
Western Meadowlark	Dieldrin	2.44 ppm	RMA 076 0736
Desert Cottontail	Dieldrin	0.04 - 1.87 ppm	RMA 076 0736, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Mourning Dove	Dieldrin	0.03 - 9.96 ppm	RMA 076 0736, RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
Cheatgrass	Dieldrin	0.07 - 0.45 ppm	RMA 037 0170-0185
Rush skeleton weed	Dieldrin	0.48 - 0.57	RMA 037 0170-0185
Prickly lettuce	Dieldrin	0.11 - 0.33 ppm	RMA 037 0170-0185
Kochia	Dieldrin	0.24 - 0.33 ppm	RMA 037 0170-0185
Tumble pigweed	Dieldrin	0.58 - 0.63 ppm	RMA 037 0170-0185
Grasshoppers	DIMP	0.17 - 0.36 ppm	RMA 076 0736
Pheasant	DIMP	0.10 - 1.54 ppm	RMA 046 2040, RMA 045 1751F
Deer Mouse	Dithiane	0.17 ppm	RMA 076 0736
Earthworms	Endrin	0.98 ppm	RMA 076 0736
Grasshoppers	Endrin	0.05 - 0.07 ppm	RMA 076 0736
Pheasant	Endrin	0.03 - 0.32 ppm	RMA 076 0736, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Western Meadowlark	Endrin	0.02 ppm	RMA 076 0736
Mourning Dove	Endrin	0.09 - 1.21 ppm	RMA 076 0736, RMA 045 1751F, RIC#85115R01, RMA 117 1364-1374
Earthworms	Isodrin	0.32 ppm	RMA 076 0736
Grasshoppers	Isodrin	0.09 ppm	RMA 076 0736
Prickly Lettuce	Mercury	0.36 ppm	RMA 037 0170-0185
Mallard	Mercury	0.29 - 1.79 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	Mercury	0.2 - 0.50 ppm	RMA 076 0736, RIC#85115R01, RMA 117 1364-1374
Western Meadowlark	Mercury	0.26 ppm	RMA 076 0736
Desert Cottontail	Mercury	1.56 ppm	RIC#85115R01, RMA 117 1364-1374
Cheatgrass	Mercury	0.40 ppm	RMA 037 0170-0185
Mallard	p,p`-DDE	0.05 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDE	0.19 - 0.32 ppm	RMA 076 0736, RMA 046 2040
Mourning Dove	p,p`-DDE	0.11 ppm	RIC#85115R01, RMA 117 1364-1374
Pheasant	p,p`-DDT	0.08 - 0.09 ppm	RMA 076 0736, RMA 046 2040

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Page 1 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
06	Pheasant	CPM Sulfone	14.5 ppm	RMA 045 1769F
06	Pheasant	Dieldrin	0.02 - 0.54 ppm	RMA 046 2040
06	Pheasant	Endrin	0.02 ppm	RMA 045 1751F
06	Pheasant	Mercury	0.32 ppm	RMA 045 1751F
06	Pheasant	p,p\`-DDE	0.02 ppm	RMA 045 1797
07	Desert Cottontail	Dieldrin	0.04 ppm	RMA 045 1797
07	Pheasant	p,p\`-DDE	0.27 ppm	RMA 046 2040
07	Pheasant	p,p\`-DDT	0.03 ppm	RMA 046 2040
09	Mourning Dove	Aldrin	0.03 - 0.09 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	CPM Sulfide	0.75 - 1.46 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	Endrin	0.14 - 0.19 ppm	RMA 046 2040, RMA 045 1769F
09	Mourning Dove	Isodrin	0.02 - 0.14 ppm	RMA 046 2040
09	Mourning Dove	p,p\`-DDE	0.04 - 0.62 ppm	RMA 046 2040
09	Mourning Dove	p,p\`-DDT	0.04 ppm	RMA 045 1797
11	Mallard	Dieldrin	0.03 - 0.57 ppm	RMA 045 1751F, RMA 031 0751F, RIC#85115R01, RMA 117 1364-1374
11	Mallard	Endrin	0.03 ppm	RMA 045 1751F
11	Mallard	Mercury	0.22 - 1.0 ppm	RMA 045 1751F
11	Mallard	p,p\`-DDE	0.03 ppm	RMA 045 1751F
11	Mallard	p,p\`-DDT	0.02 ppm	RMA 045 1751F
12	Blue-Winged Teal	Aldrin	0.16 ppm	RMA 046 2040
12	Mallard	Aldrin	0.05 ppm	RMA 046 2040
12	Mourning Dove	Aldrin	0.07 ppm	RMA 046 2040
12	Mourning Dove	CPM Sulfide	0.2 ppm	RMA 046 2040
12	Mallard	Copper	9.6 - 14.4 ppm	RMA 162 0821F
12	Blue-Winged Teal	Dieldrin	0.41 ppm	RMA 046 2040
12	Mallard	Dieldrin	0.06 - 0.97 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
12	Mourning Dove	Dieldrin	0.07 - 0.27 ppm	RMA 046 2040
12	Blue-Winged Teal	Endrin	0.23 ppm	RMA 046 2040
12	Mallard	Endrin	0.03 - 0.17 ppm	RMA 046 2040, RMA 162 0821F, RMA 045 1751F
12	Mourning Dove	Endrin	0.1 - 0.2 ppm	RMA 046 2040
12	Mourning Dove	Isodrin	0.11 - 0.22 ppm	RMA 046 2040
12	Blue-Winged Teal	Mercury	8.9 ppm	RMA 046 2040
12	Mallard	Mercury	0.51 - 21.8 ppm	RMA 046 2040, RMA 162 0821F, RIC#85115R01
12	Mallard	p,p\`-DDE	0.04 - 0.30 ppm	RMA 162 0821F, RMA 045 1751F, RIC#85115R01
12	Mourning Dove	p,p\`-DDE	0.03 - 0.24 ppm	RMA 046 2040, RMA 045 1751F
12	Blue-Winged Teal	p,p\`-DDT	0.12 ppm	RMA 046 2040
12	Mallard	p,p\`-DDT	0.02 - 0.03 ppm	RMA 045 1751F

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Continued, Page 2 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
19	Muskrat	p,p`-DDE	0.15 ppm	RFA 003 0659-0661
23	Mourning Dove	Aldrin	0.03 ppm	RMA 046 2040
23	Cheatgrass	Aldrin	0.05 ppm	RMA 037 0170-0185
23	Kochia	Copper	5.0 - 8.0 ppm	RMA 037 0170-0185
23	Prickly Lettuce	Copper	1.0 - 13.0 ppm	RMA 037 0170-0185
23	Canadian thistle	Copper	7.0 - 17.0 ppm	RMA 037 0170-0185
23	Cheatgrass	Copper	1.0 - 11.0 ppm	RMA 037 0170-0185
23	Mourning Dove	CPM Sulfide	0.3 ppm	RMA 046 2040
23	Canadian thistle	CPM Sulfone	1.0 - 2.84 ppm	RMA 037 0170-0185
23	Kochia	CPM Sulfone	1.47 - 2.28 ppm	RMA 037 0170-0185
23	Cheatgrass	CPM Sulfone	2.16 - 3.68 ppm	RMA 037 0170-0185
23	Cheatgrass	CPM Sulfoxide	0.27 - 0.64 ppm	RMA 037 0170-0185
23	Pheasant	DBCP	0.03 ppm	RMA 046 2040
23	Desert Cottontail	Dieldrin	0.05 - 0.06 ppm	RMA 045 1751F
23	.Kochia	Dieldrin	0.22 - 0.28	RMA 037 0170-0185
23	Canadian Thistle	Dieldrin	0.10 - 0.68	RMA 037 0170-0185
23	Cheatgrass	Dieldrin	0.04 - 0.08	RMA 037 0170-0185
23	Canadian Thistle	DIMP	0.50 - 14.88 ppm	RMA 037 0170-0185
23	Mourning Dove	DIMP	0.1 ppm	RMA 046 2040
23	Prickly Lettuce	DIMP	1.88 - 14.64 ppm	RMA 037 0170-0185
23	Cheatgrass	DIMP	0.10 - 0.15 ppm	RMA 037 0170-0185
23	Kochia	DIMP	0.22 - 18.15 ppm	RMA 037 0170-0185
23	Mourning Dove	Endrin	0.2 - 0.25 ppm	RMA 046 2040
23	Mourning Dove	p,p`-DDE	0.13 - 0.24 ppm	RMA 046 2040
23	Canadian Thistle	p,p`-DDE	0.18 - 0.21 ppm	RMA 037 0170-0185
23	Mourning Dove	p,p`-DDT	0.1 ppm	RMA 046 2040
23	Cheatgrass	Mercury	0.24 ppm	RMA 037 0170-0185
30	Pheasant	Dieldrin	0.06 ppm	RMA 046 2040
30	Mourning Dove	Dieldrin	0.17 - 0.51 ppm	RIC#85115R01
30	Pheasant	Endrin	0.04 ppm	RMA 046 2040
30	Mourning Dove	Endrin	0.02 0.04 ppm	RIC#85115R01
30	Pheasant	p,p`-DDE	0.08 - 0.10 ppm	RMA 046 2040
35	Mourning Dove	CPM Sulfone	0.22 ppm	RMA 045 1751F

Table 2.3-5. Contaminants in Biota From Sections 6, 7, 11, 12, 19, 23, 30, and 35 (Continued, Page 3 of 3)

Section	Species Represented	Contaminant	Amount Range ppm (parts per million)	Reference
00	Lizards/Bullsnakes	Aldrin	0.06 - 0.07 μg/g	RMA 076 0751
		Copper	2.0 μg/g	RMA 076 0751
		Dieldrin	0.06 - 3.78 μg/g	RMA 076 0751
		DIMP	0.31 μg/g	RMA 076 0751
		Endrin	0.12 μg/g	RMA 076 0751
		p,p`-DDT	0.09 μg/g	RMA 076 0751
00	Beetles/Grasshoppers	Aldrin	0.17 - 0.70 μg/g	RMA 076 0753
		Copper	20.4 - 37/6 μg/g	RMA 076 0753
		Dieldrin	0.08 - 5.38 μg/g	RMA 076 0753
		DIMP	0.17 - 0.71 μg/g	RMA 076 0753
		Dithiane	0.35 μg/g	RMA 076 0753
		Endrin	0.05 - 0.07 μg/g	RMA 076 0753
		Isodrin	0.09 - 0.17 μg/g	RMA 076 0753
		$PCPMSO_2$	0.11 - 2.94 μg/g	RMA 076 0753
		PCPMSO	0.27 - 1.11 μg/g	RMA 076 0753
		p,p`-DDE	0.06 - 0.08 μg/g	RMA 076 0753

biota in relation to potential pathways of contamination for major animal communities on RMA are discussed in Section 2.4.

2.3.2 CONTAMINANT EFFECTS ON BIOTA

Most chemical analyses of plant and animal tissues for contamination have been conducted on species associated with potential major sources of contamination. Several were associated with observed effects on species. Some of these effects are within the definition of injury to biological resources as defined in the NRDA. According to 43 CFR Section 11.62(f), an injury to a biological resource has resulted from a chemical contaminant if the concentration of the substance is sufficient to:

1. Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations; or
2. Exceeds action or tolerance levels established under Section 402 of the Food, Drug, and Cosmetic Act, 21 U.S.C. 342 in edible portions of organisms; or
3. Exceeds levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organisms.

Of the seven manifestations of injury described in the injury definition, one (genetic mutation) currently has no methods of determination which meet the criteria of acceptance under the NRDA regulations, and two others (cancer and disease) have only single limited methods of determination each which meet these proposed acceptance criteria. Each of the four remaining manifestations of injury have been documented in relation to chemical contamination associated with particular sites/ sources of contamination on RMA. Observed incidents of wildlife injury on RMA associated with contaminants and contaminant sources are summarized in Table 2.3-6 together with references to supporting documentation for these observed effects.

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Page 1 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
1949-1959	Ducks	Lower Lakes (and Basin F)	Death (20,000 minimum)	Unknown	RFA 003-0107F
1952	Ducks	Lower Lakes	Behavior Abnormality and Death (Test vs Control Areas As Well)	Unknown	RSH 855 1544F RMA 036 1495F
1955	Duck	Lower Lakes	Death	High level of Dieldrin	RSH 855 1544F RMA 036 1495F
1959-1960	Leopard Frog Chorus Frog (Tadpoles)	Lower Lakes	Dead	Aldrin, dieldrin, in water, mud, snails, algae	RSH 855 1544F
03/28/62	Ducks	Lower Lakes	Death (>100)	High dieldrin levels	RSH 855 1544F
01/66-05/66	Waterfowl	Lower Lakes	Death (163)		RFA 003 0039
05/16/73	Large Mouth Bass Bluegill Catfish	Lower Lakes	Fish Kill/Death	Aldrin released into lakes prior to fish kill	RDA 002 1865 RIC#84131R02 RMA 036 1495
06/09/82	Great Blue Heron	Lower Lakes	Found Dead	Dieldrin, endrin, DDE, Heptachlor Epoxide Polychlorinated biphenyls	RFA 003 1673;
06/09/82	Muskrat	Lower Lakes	Found Dead		RFA 003 0301
05/05/82	Eared Grebe	Lower lakes	Found Dead		RFA 003 0301
05/14/82	Magpie	Lower Lakes	Found Dead		RFA 003 0301
04/73	Ducks	Basin C	Death (136)	Dieldrin in mud, water, tissue	RIC#84131R02
04/73-05/73	Ducks	Basin F	Death (Large Numbers)	Aldrin, dieldrin in tissue	RDA 002 1865
05/73	Toads	Basin D	Death, Physical Deformity	Dieldrin in tissue	RIC#84131R02; RDA 002 1865
1974	Ducks	Basin F	Death	"Detergents" Wet Feathers-Caused loss of body heat	RMA 046 0975F

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Continued, Page 2 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
06/24/75	Western Grebe (2)	Basin F	Death	High Aldrin, Dieldrin Levels	RFA 002 0262F
	Ruddy Duck (1)	Basin F	Death		RFA 002 0262F
	Coot (1)	Basin F	Death		RFA 002 0262F
05/01/75-05/02/75	Grebe	Basin F	Death (291 Birds Total)		RSH 855 1544F
	Coot	Basin F	Death		RSH 855 1544F
	Merganser	Basin F	Death		RSH 855 1544F
	Ducks	Basin F	Death		RSH 855 1544F
	Buteo Hawks	Basin F	Death		RSH 855 1544F
	Burrowing Owl	Basin F	Death		RSH 855 1544F
	Pheasants	Basin F	Death		RSH 855 1544F
	Songbirds	Basin F	Death		RSH 855 1544F
	Shorebirds	Basin F	Death		RSH 855 1544F
	Loon	Basin F	Death		RSH 855 1544F
06/80	Migratory Birds	Basin F	Death (375)		RDA 005 1726
10/80-12/80	Waterforwl	Basin F	Death (49)		RDA 005 1726
05/25/82	Bullock Oriole	Basin F	Death		RFA 003 0301
04/06/82	Gadwall	Basin F	Death		RFA 003 0301
05/25/82	Brewer's Blackbird	Headquarters	Death		RFA 003 0301
05/14/82	Starling	Headquarters	Death		RFA 003 0301
06/23/82	Pheasant	North Bog	Death		RFA 003 0301
03/01/82	Red Tail Hawk	Section 6	Death		RFA 003 0301
03/29/82	Red Tail Hawk	Section 36	Death	Dieldrin, endrin, DDE Heptachlor Epoxide Polychlorinated biphenyls	RFA 003 0301
1982	Kestrel	RMA	Physiologic Malfunction Eggshell Thinning	High dieldrin levels in eggshell	RMA 134 0649; RFA 002 0061 RFA 003 0290

Table 2.3-6. Wildlife Injury Incidents, Miscellaneous or Unknown Locations (1949 to 1982) (Continued, Page 3 of 3)

Date	Species	Location	Injury Category	Apparent Cause of Death	Reference
Fall 1981	Mallard (1)	Unknown	Behavior Abnormality and Death	Dieldrin, DDE, Endrin, PCB	RFA 003 0704F
06/76	Starlings	Unknown	Death	High dieldrin levels in tissues	RIC#83020R03
06/76	Red-Tailed Hawk	Unknown	Death	High dieldrin levels in tissues	RIC#83020R03
11/03/76	Great Horned Owl	Unknown	Death*	Pesticides, unknown	RMA 153 2150F
12/08/76	Coyote	Unknown	Death*		RMA 153 2150F
03/07/77	Starling	Unknown	Death*		RMA 153 2150F
03/18/77	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
04/12/77	Starling	Unknown	Death*		RMA 153 2150F
04/18/77	Rainbow Trout	Unknown	Death*		RMA 153 2150F
12/08/77	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
04/05/78	Marsh Hawk	Unknown	Death*		RMA 153 2150F
01/29/79	Ferruginous Hawk	Unknown	Death*		RMA 153 2150F
02/27/79	Rough-Legged Hawk	Unknown	Death*	Significant concentrations of CPM sulfone in tissue	RMA 153 2150F
03/30/81	Canada Goose	Unknown	Death*	Pesticides, unknown	RMA 153 2150F

* Concentrations of pesticides were found in animal.

2.3.2.1 Death

Laboratory toxicity testing, documented fish kills, and observations of animals found dead on RMA have been conducted in connection with tissue analyses which document this adverse effect on biota. Existing documentation from 1949 to the present indicate that thousands of individuals of fish, waterfowl, and other animal species have died as a result of RMA contamination (Table 2.3-6). Additional investigations of the distribution and extent of this contamination in relation to biological resources are necessary in order to quantify damage to biological resources and to determine existing areas of contamination because the chemicals implicated in the death of these organisms are still present in the RMA environment.

2.3.2.2 Behavioral Abnormalities

Waterfowl which have been observed in the lower lakes area have exhibited clinical signs of abnormal behavior associated with organochlorine contamination (e.g., flying into buildings, attempting to land while several feet above the ground). The observed abnormal behavior was documented in association with high contaminant levels in the tissues of these birds (see references to this observation in Table 2.3-6). Recent observations at Basin F indicate that similar behavioral effects may be associated with chemicals present in the water of this known contaminant source.

2.3.2.3 Physiological Malfunctions

Eggshell thinning and reduced avian reproduction are well documented effects of organochlorine pesticides. These effects have been documented for one bird species, the American kestrel, from RMA (Table 2.3-6). These investigations were conducted as a controlled experiment comparing offpost (control) and onpost (experimental) areas to document the relationship between chemical contaminants in tissues and the observed adverse effects. Pathways analysis (Section 5.0) suggests that other resident breeding species may have been similarly affected, but documentation is lacking.

2.3.2.4 Physical Deformations

Physical deformations have been observed in toads from Basin D (Table 2.3-6). While this animal group is not of primary concern as a key species in animal communities at RMA, it suggests that similar effects may have occurred or may still affect other wildlife species.

2.4 PRELIMINARY PATHWAY IDENTIFICATION

An analysis of the movement of contaminants to and through the biota is necessary in order to identify any resources which have been or may be impacted. Biota may become contaminated through a variety of pathways including air, drinking water, and contact with soil. Once a contaminant has become incorporated into a plant or animal species it may be consumed by an animal species and be transferred to other biota through a complex system of pathways. Consequently, pathway identification for biota requires analytical approaches substantially different from those which apply to physical resources such as soil, air, and water.

The examination of food chain relationships is a logical and accepted mechanism for the analysis of pathways through plant animal communities. Food chain analysis is indicated as an accepted approach in both the NCP and NRDA.

2.4.1 FOOD WEB ANALYSIS

A food chain is a pathway for the movement of energy and nutrients (potentially including contaminants) through a series of organisms by progressive levels of consumption. The sequence where a plant is eaten by one animal which is in turn eaten by another animal, and so on constitutes a food chain (Elton, 1927).

The interconnected food chains in an animal community form a food web which is a representation of the feeding relationships among all organisms in a community. As such, a food web is a model which permits the identification of pathways for the movement and accumulation of contaminants in the biota. Except in instances where one species feeds entirely on another, more than one food chain will be involved.

Consequently, food chain determination is best achieved by food web analysis.

Food web analysis as adapted for pathways identification proceeds stepwise from a general and comprehensive level to a systematic evaluation of food chains which can impact general ecosystem function, adversely affect key species within the animal community, or provide a pathway for contaminant transfer to humans. The approach used herein applies standard methods for food web analysis, systematically organized to determine potential pathways of contaminant movement through the biota. Figure 2.4-1 outlines the steps in this food web analysis which are described in the following sections.

2.4.1.1 Definition of Animal Communities

The first step in food web development was to define which animal communities are potentially affected by the contamination. Species lists were compiled for plants and animals known or thought to occur on RMA (Appendix A). Sources consulted for this information included environmental impact assessments (Federal Aviation Administration 1985, Fairbanks and Kolmer, 1976, RIC#84219R01), regional wildlife literature (CDOW 1981, 1982a, 1982b; Lovell and Choate, 1982), data from reports and collections at RMA (U.S. Army Dugway Proving Ground, 1974, RIC#81324R30), and recent onsite observations. Because of their higher visibility and importance to humans, more detailed information (e.g., species) was available for higher plants (e.g., grasses, shrubs, trees) and for vertebrates (e.g., fish, mammals, birds) than for the lower taxonomic categories (e.g., algae, invertebrates).

Species and animal groups were then organized into the three major animal communities indicated above. Species which feed in more than one community (e.g., raptors, amphibians) were included in each food web as appropriate. Because contaminants have been documented as present in the physical environment of the three major regional ecosystems (see Section 2.1.2), the species and groups in all three community food webs were considered in this analysis.

PRELIMINARY FOOD WEB ANALYSIS

1. Define Animal Communities
   - List species in each major ecosystem potentially contaminated
   - Include plant base for plant based food webs
   - Based on general and regional literature and limited onsite observation

2. Determine Food Habits
   - Food classified by percent animal and percent plant material
   - Species grouped by general food categories
   - Based on general and regional literature

3. Construct Food Web Database
   - Computerized database developed for each species based on food habits data
   - Food species grouped by taxonomic status (e.g. ducks) or growth form (e.g. shrubs)

4. Analyze Source and Sink Food Webs
   - Develop list of key species
   - Construct source and sink food webs from computerized database
   - Evaluate source and sink food webs
   - Present / prioritize potentially important source and sink food webs and / or food chains for each major animal community

Figure 2.4-1
STEPS IN PRELIMINARY
FOOD WEB ANALYSIS

See text for explanation

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

2.4.1.2 Food Habits Determination

Preliminary definition of the feeding relationships among organisms in each food web was based on published information on the general food habits of species and animal groups (Hammerson, 1982; Bellrose, 1980; Baxter and Simon, 1970; Martin et al., 1951). Supplemental regional sources and direct observation confirmed much of the general information provided by these sources but did not provide data indicating an expansion of potential pathways beyond those indicated in the general references.

Food is classified as percent plant and percent animal material, and species are grouped into general food habits categories (e.g., herbivore, carnivore, omnivore). General data on food habits are sufficient to provide a preliminary determination of potential pathways, in spite of the lack of comprehensive and detailed food habit studies from the site and the adjacent area.

2.4.1.3 Food Web Database Construction

The information on food habits was then organized according to the broad feeding categories of herbivores (plant eaters), carnivores (animal eaters), omnivores (animals which consume plant and animal material), and detritivores (animals which consume decomposed organic material). Parasites were not specifically addressed because adverse effects on this group as a result of contamination would be difficult to demonstrate. Within these broad categories, species which potentially occur on RMA were grouped according to taxonomic classification (e.g., lagomorphs, rodents, etc.) or by growth form (e.g., trees, shrubs, forbs, etc.).

A computerized food web data base was then created which indicated broad categories and food groups consumed by each species or animal group on the comprehensive species list. The percent of each category consumed by each species was also indicated. In instances where these percent estimates varied seasonally, the seasonal percents were averaged to provide a rough estimate of the annual percent consumed.

Once the comprehensive food habits database was developed, it was used to determine potential pathways (e.g., food chains) for the movement of contaminants through regional food webs. This was accomplished by manipulating the database to determine possible feeding relationships among species based on general food habits information.

2.4.1.4 Source and Sink Food Web Analyses

The interactions of all species and groups within an animal community constitutes the community food web. Tracing all possible pathways for contaminant movement through community food webs which include more than a few species, such as those at RMA, would be complex and time consuming. A more manageable approach is to first examine the trophic (feeding) relationships for key species in each community food web. For purposes of the preliminary pathway determination, key species are defined as:

- Species listed as rare, threatened, or endangered either federally or by the state of Colorado;
- Species of economic importance (e.g., game animals, furbearers, pests, etc.) including those species consumed by humans (e.g., ring-necked pheasant, cottontails, waterfowl, and mule deer);
- Abundant or common in the respective animal communities;
- Prominant species at each trophic level in regional food webs which may be affected by RMA contaminants; and
- Species which are known to contain RMA contaminants.

In instances where a number of animals occupy the same trophic level, have the same feeding habits, and meet the same criteria of key species (e.g., dabbling ducks), one species was selected as representative of the group. The species selected for analysis and the rationale for their selection are presented in Table 2.4-1. The abundance estimates for each species on this table are based on regional publications and in some cases may not be representative of populations on RMA. Limited field observations conducted as part of the Biota Assessment have confirmed the presence of some species, but no quantitative population estimates have been made. Because it is based on existing documents and limited field observation it contains some species whose occurrence at RMA is of low probability.

Table 2.4-1. Species Selected for Preliminary Food Web Analysis from Computer Database

Common Name	Criteria for Selection[1]
AQUATIC FOOD WEB	
Bluegill	game, small carnivore, common
Black Bullhead	game, bottom feeder/omnivore, common
Largemouth Bass	game, large carnivore, common
Northern Pike	game, top carnivore, common
Tiger Salamander	Feeds in aquatic and wetland communities, common
WETLAND FOOD WEB	
American Coot	omnivore, abundant
Canada Goose	game, grazer/surface feeder, abundant
Mallard	game, dabbling duck, abundant
Redhead	game, diving duck, fairly common
Great Blue Heron	carnivore, fairly common
Black-crowned Night Heron	carnivore, fairly common
Red-winged Blackbird	omnivore, abundant
GRASSLAND FOOD WEB	
Magpie	omnivore/scavenger, abundant
Mourning Dove	game, herbivore, abundant
Ring-necked Pheasant	game, herbivore, abundant
Western Kingbird	aerial insectivore, common
Western Meadowlark	terrestrial insectivore/omnivore, common
American Kestrel	carnivore, fairly common
Red-tailed Hawk	top carnivore, common
Badger	terrestrial carnivore, common
Desert Cottontail	game, herbivore (grazer), abundant
Mule Deer	game, herbivore (browser), abundant
Pocket Gopher	fossorial herbivore, common
Bullsnake	poikilothermic carnivore, fairly common

[1] Information sources are provided in Appendix A

Once key species were selected, source and sink food webs were developed for each species. A "source" food web includes a designated "source" species plus all of the organisms that consume the source, plus all of the organisms that eat those species, and so on to the highest trophic level involved (Cohen, 1978). A "sink" food web is a subset of a community food web which includes all of the kinds of organisms that the designated "sink" species eats, the food of these organisms, and so on to the lowest level of the food web (Cohen, 1978).

Visual inspection of these levels for each species is then conducted to determine important and/or representative food chains. Identification of food chains involving more than one key species were evaluated to determine the potential importance of these species at a particular level within a chain in terms of the transfer and/or bioaccumulation of chemical contaminants. While key species and important food chains can be identified by other methods, this systematic analysis ensures that all possible interrelationships have been examined in the context of the potential for RMA contamination.

2.4.2 CONTAMINATION PATHWAYS AT RMA

Chemical contaminants were first identified as present in the tissues of plants and animals from RMA during the mid-1950's. Since that time numerous studies have been conducted on selected plant and animal species to determine the occurrence of specific chemicals in selected species, usually in reference to specific contamination problems at a few locations on RMA. The types of chemicals targeted for analysis, species analyzed, and location in past studies were sampled in relation to specific problems. In the three decades of contamination studies at RMA there have been no comprehensive investigations of contamination distribution or effects on biota. While there is abundant information documenting the presence of chemical contamination in RMA biota (which in many cases can be related to adverse effects on selected sites and species), there is no overall assessment of the chemicals harmful to biota, distribution of contaminants in ecosystems, and sites of contaminant transfer to biota. Studies documenting current information on contaminant distribution in biota are summarized in Section 2.3.

2.4.2.1 Food Web Analyses

Food web analyses as described in Section 2.4.1 provide a comprehensive, systematic, and objective approach for evaluating pathways of movement of contaminants through the plant and animal communities (biota) in ecosystems potentially affected by contamination. This approach is useful in evaluating potential contamination, particularly if environmental contamination has just occurred and chemical analyses verifying contamination in biological resources is unavailable. Most situations of this type would involve a single ecosystem involving species in a single animal community, thus simplifying the determination of potential pathways.

Food Web Database Studies

Circumstances of environmental contamination at RMA differ substantially from the typical situation described above. Varying levels of contamination have occurred at numerous potential locations on RMA since RMA was developed by the U.S. Department of Army (USATHAMA, 1983, RIC#83326R01). More than 50 target chemicals have been identified from a list of over 700 potential RMA contaminants. As previously mentioned, numerous studies have been conducted on selected sites and species for some target chemicals over the past three decades. In addition, the sites of known and potential contamination occur in three major ecosystems: grassland, wetland, and aquatic. The evaluation of contamination impacts on biota at RMA is therefore extremely complicated in comparison to most hazardous waste sites. RMA is a conglomeration of many sites with different amounts and concentrations of chemicals added to the environment at different times, and involving different combinations of plant and animal species. For these reasons, a routine food web analysis is of limited usefulness.

Because of the number of key species potentially affected by RMA contaminants and the complexity of probable feeding interactions, food web analyses described in Section 2.4.1 indicated that most species in all trophic levels of each of the three major food webs were potentially exposed to chemical contaminants.

Results suggesting exposure levels and extent were obtained by examination of the computerized food web for key species listed in Table 2.4-1. These species were selected on the basis of criteria listed in Section 2.4.1.4. All of the species are known or expected to be common or abundant components of regional ecosystems, and many are of economic importance. In general terms, the higher the trophic level occupied by a species, the more likely it is to occur on an exposure pathway, and in instances where the chemical bioaccumulates, the more likely the species is to suffer injury. Work on chemical contamination in aquatic ecosystems on RMA conducted by the U.S. Fish and Wildlife Service (Rosenlund, et al., 1986, RIC#86041R02) provides a discussion and suggested approach for estimating rates of bioaccumulation of contaminants in the aquatic environment. Other methods for estimating the transfer and/or bioaccumulation of selected contaminants are discussed in Lyman, et al. (1982). These approaches were not employed in this preliminary assessment of contamination in biotic resources at RMA. Use of these formulas is inappropriate because of the absence of quantitative data on contaminant levels in some key species; the lack of correspondence in chemicals analyzed among species, sites, and years; and the lack of equivalent data on chemicals and species for all similar sites.

The abundant data on contaminants in RMA biota obtained during previous investigations were used to determine if the general conclusion regarding the pervasive distribution of contaminants in major food webs could be verified. Information on contamination occurrence in species which is summarized in Tables 2.3-1 through 2.3-5 was used to evaluate potential movement along pathways indicated in source and sink food webs developed for key species. In all cases these data supported the possibility predicted in these model food webs that chemical contamination occurs at all trophic levels sampled in each of the three major food webs. Table 2.4-2 presents a summary of the species in which contaminants have been found in relation to the trophic structure of regional food webs.

Aquatic Ecosystem Studies

Work on contaminants in RMA aquatic systems done by the U.S. Fish and Wildlife Service (Rosenlund, et al., 1986, RIC#86041R02) focused on

Table 2.4-2. Biota Containing Contaminants on Rocky Mountain Arsenal in the Trophic Levels of Major Ecosystems

Trophic Levels	Major Ecosystems: Aquatic	Wetland	Grassland
Plant (producer)	algae	cattails	grasses, forbs
Invertebrate	snails	snails	grasshoppers, beetles
herbivore	-	-	
carnivore	-	-	beetles
detritivore	-	-	earthworms
parasite	leech	leech	-
Vertebrate			
herbivore[1]	plains spadefoot toad, chorus frog, leopard frog	Canada goose, gadwall, green-winged teal, muskrat	mourning dove, ring-necked pheasant, desert cottontail, black-tailed prairie dog, deer mouse
carnivore/ omnivore	black bullhead, channel catfish, rainbow trout, bluegill, tiger salamander	redhead, blue-winged teal, golden eye, mallard, American coot, shoveler, pintail, ring-necked duck, common merganser	ring-necked pheasant (young), robin, western meadowlark
higher carnivore	largemouth bass, northern pike	great blue heron	red-tailed hawk, American kestrel, rough-legged hawk, great horned owl, starling, bullsnake, lizard

[1] Frogs and toads as tadpoles; waterfowl with plants as 90% or more of diet

levels of aldrin, dieldrin, endrin, and mercury. Of 173 samples analyzed in this study the results can be summarized as follows:

- Aldrin:

  One sample exceeded FDA guidelines (0.3 ppm)
  Range = bdl to 0.33 ppm
  Water, dragonflies, damselflies, and snails were bdl in all lakes. Aldrin levels were highest in Lower Derby Lake where it bioaccumulated in viscera of predator fish (mean levels for largemouth bass = 0.300ppm).

- Dieldrin:

  16 samples exceeded FDA guidleines (0.3 ppm)
  Range = bdl (water and damselflies) to 6.5 ppm (bass viscera).
  Dieldrin levels from Lower Derby Lake suggest the extent to which dieldrin is bioaccumulated in the viscera of predator fish species:
  5.387 ppm - bass viscera
  1.043 ppm - pike viscera
  0.216 ppm - plankton

- Endrin:

  17 samples exceeded FDA guidlelines (0.3 ppm)
  Range = bdl (water, aquatic insects) to 0.21 ppm (bass viscera).
  As with dieldrin, endrin appears to bioaccumulate through trophic levels, to a high in bass viscera.

- Mercury:

  15 samples exceeded FDA guidelines (1.0 ppm)
  Range = bdl (water) to 3.45 ppm (pike fillets)
  Mercury appears to accumulate to the greatest extent in fillets.

Of the 26 Lower Lakes species in which contaminants have been found, six have a completely carnivorous diet. Two of the species discovered with contaminants are plants (Table 2.4-2). The remaining 18 species have diets composed of between 24 and 100 percent plant.

Aquatic plants are able to bioaccumulate mercury to 100 percent of the levels reported in sediments, and to almost one-half of the 1.0 ppm FDA mercury guideline levels for fish (Rosenlund, et al., 1986, RIC#86041R02). The continued documented presence of mercury within the primary trophic levels of the ecosystem suggest that its spread to higher trophic levels will continue.

2.4.2.2 Other Pathways of Contamination

As previously stated, food chains are the principal route for the contamination of most animal species. Potential pathways exist for the movement of contaminants from the physical environment into both plant and animal species on and near RMA. These pathways have been implicated in the initial incorporation of contaminants into biota, and then to other species by means of feeding interactions within community food webs. The principal routes of contaminant movement from the physical environment to biota are discussed below in relation to major animal communities and key species which have been documented as containing chemical contaminants.

Air

Past investigations of contaminants in air at and near RMA suggest that this pathway is of little potential importance in the contamination of biota. Documented spills and disposal of volatile chemicals have occurred on RMA in the past and have been investigated with respect to potential risk to humans. Although it is possible that some individuals have been harmed by inhalation of chemicals, large scale injuries were not observed, and it is unlikely that injury to plants or animals via the air route were substantial.

Non-volatile substances which are toxic and/or carcinogenic may have been incorporated into biota and produced harmful effects as a result of the suspension of small particles in the air during periods when contaminated areas of bare ground were subjected to surface winds. These injuries, if any, were not observed in the past. If injuries due to the air route did occur, it is likely that the effects were slight, and that the resulting injuries were localized. Most of the potential injury which may have occurred by this route would have taken place when disposal sites and

spills were fresh. The length of time intervening between most spills and disposal activities in the 1950's and 1960's and the present would have allowed all but the most persistent and abundant chemical contaminants to have dissipated into other compartments of the environment or to have degraded into non-hazardous substances.

Soil/Sediments

Biota contamination through soil and/or sediments is potentially important. Investigations of the Lower Lakes, connecting waterways, and North Bog indicate that biota in these areas have incorporated contaminants into their tissues and have exhibited several types of injury (Section 3.0). The contaminants in these species of plants and animals were also present in the sediments. Some of these chemicals such as dieldrin are present in high concentrations in sediments, are persistent in the environment (Section 2.0) and are known to bioaccumulate. Initial findings of EBASCO's Phase I studies and recent studies (Rosenlund, et al., 1986, RIC#86041R02) indicate that sediments and biota in the Lower Lakes are still contaminated, and provide a discussion of the routes of this contamination from the sediments through the components of the food web of the aquatic ecosystem.

Incorporation of contaminants into plants occurs through direct exposure. Animals may become contaminated through direct exposure and incorporation of contaminants through the skin or by ingestion of contaminants in sediments. The latter route is particularly important for bottom-feeding species such as bullheads and catfish.

Ingestion of soil is a recognized route of exposure for terrestrial organisms, particularly grazing species (e.g., prairie dogs). Direct exposure and ingestion are potential contaminant exposure routes which may affect burrowing species such as pocket gophers and prairie dogs. Pocket gophers which feed on underground plant parts (e.g., roots) and spend nearly all of their lives in burrows may be particularly at risk from this contamination route.

Water

Biota contamination by means of water can occur by a variety of routes. Exposure of aquatic species is direct through tissues which are permeable to contaminants. This exposure includes direct bioconcentration through the exposed tissues. Bioaccumulation of selected contaminants is also likely. Organochlorine compounds (pesticides) have been documented in the sediments and several trophic levels in the aquatic food web (Section 3.0). Although direct exposure to sediments is implicated in contaminant uptake by biota, the role of water may be involved to some extent.

Terrestrial species including waterfowl, gamebirds, small game mammals, and large game (e.g., mule deer) regularly drink surface water. In areas contaminated with chemicals, uptake of chemicals from the drinking water and from associated sediments may provide an important pathway for incorporating these contaminants into the terrestrial food web.

3.0 PHASE II SAMPLING PROGRAM

Phase I results and additional regulatory guidance since the initiation of the Biota Assessment task indicate a need for additional field studies of biota in relation to contamination at RMA. Data from Phase I investigations of other resources (e.g. soil, ground water, surface water) have better defined areas of contamination at RMA and have been used in the development of the sampling program presented in this section.

The subtasks described below are designed to obtain pertinent information on the distribution, concentration, and effects of contaminants on biota on and near the RMA. Procedures were selected in order to obtain information necessary for appropriate remediation of contamination sites and assuming that restoration/replacement will be used as the basis for damage determination rather than diminution of use values. Cost-effectiveness and reasonable cost have been used in addition to technical adequacy criteria in the development of this program.

3.1 SITE CHARACTERIZATION

Studies will be done to assess current background biota conditions for each major contamination site, and for their corresponding control sites. Because historical data for RMA and vicinity are sparse, control areas will be used to establish baseline conditions, in accordance with the guidelines outlined in the NRDA. Control sites will provide a natural baseline against which variables affecting biotic systems on RMA may be measured. The goals of site characterization include:

- To measure the extent to which the injured resource differs from baseline (control) to determine the change attributable to contamination;
- To provide estimated numbers of affected individuals, or percent area of total resource affected; and
- Note any unusual phenomena (e.g., behavior) which might indicate contaminant effects.

Major sites of contamination identified with known and potential effects on biota have been identified and discussed in Section 2.0. These contamination sites (South Plants/Basin A, the Lower Lakes, Basin F, Basins C, D, and E, and the North Bog) will be discussed in succeeding sections in terms of biota assessments proposed for them. CAR's produced by ESE and EBASCO will be used to delineate the most likely contaminant locations, and direction and means of contaminant migration.

Control areas will be selected on the basis of their similarity to contaminated areas and their lack of exposure to contaminants. Their comparability will be demonstrated on a site by site basis. Control areas for invertebrate and plant studies will be matched to contaminated areas by exact soil type wherever possible. Soil types will be those described by county soil survey reports published by the Soil Conservation Service and the Colorado Agricultural Experiment Station.

3.1.1 SOIL-ASSOCIATED INVERTEBRATES

Invertebrate species such as earthworms, whose life medium is the soil, are good bio-indicators of soil contamination. Earthworms will be sampled in contaminated areas (onsite) and uncontaminated areas (on and offsite) to provide information on population levels.

To the extent possible, transects will be located in association with previous soil study areas, so that information already obtained may be used to assess the results of soil invertebrate studies. Invertebrate population sampling is discussed in Section 3.6.

Transect locations will be chosen within appropriate areas on the basis of soil maps and Soil Classification System (SCS) soil descriptions that will be evaluated for all earthworm sampling areas associated with contamination sites.

3.1.2 VEGETATION

Vegetation sampling techniques will conform as closely as possible to those proposed by MKE so that opportunities for data comparison will be maximized. Transects will be located in association with contamination

sites in order to sample any effects specifically related to types or degrees of contamination. This transect location strategy may differ from the apparently random one chosen by MKE, whose transects may not be necessarily associated with contamination sites. The MKE random sampling strategy may be insufficient to detect vegetation differences between contaminated and uncontaminated areas. The MKE transect location maps will be reviewed when available to determine if enough transects are located in proximity to designated contamination sites.

The vegetation sampling scheme is designed with ten 100 m transects in each major soil/vegetation type associated with the major sources of contamination described in Section 2.1 (closely associated pairs of 50 m transects may be used instead of single 100 m transects). SCS soils maps were superimposed on the vegetation map in order to determine areas where major soil and vegetation types occurred in relation to contamination sites. No transects will be located in areas where the soil is known to be greatly disturbed, as in areas around the lakes where dredged material has been dumped.

Control areas were selected both onpost and offpost. Onpost control areas were determined through a review of information available in the ESE and EBASCO CAR's. The same soils and vegetation types used for contaminated areas will be used for onpost control areas. Thus, a sunflower-dominated vegetation community occurring on a Tructon loam near a contamination source will have an onpost control area of sunflowers on a Tructon loam. Offpost control areas will be selected on the basis of the same soil types. Areas such as Wellington Wildlife Refuge will be used, where grazing has not occurred for many years. Table 3.1-1 presents the proposed number of transects per soil and vegetation type for onpost sampling sites and control areas. Numbers entered under headings such as Soil Type indicate the number of categories under that heading to be sampled: e.g., 2 soil types will be sampled in Basin A.

Onpost transects, in most cases, will be located within sight of ground water wells and soil boring locations. There are several reasons for the frequent association of transects with well and boring locations:

Table 3.1-1. Vegetation Sampling Scheme for Site Characterization.

Location	Soil Type	Vegetation Type	Minimum Number of 100 m Transects
Basin A	2	1	10
Basin C	1	1	5
Basin D	1	1	5
Basin E	1	1	5
Basin F	2	1	10
Lower Lakes	1	1	10
Onpost Controls	2	1	20
Offpost Controls	2	1	20

- o Ease of location on maps, and in field, because all wells and borings have surveyed coordinates;
- o Randomness, because wells and borings were randomly placed using a grid system; and
- o Use of data derived from well water and soils analyses, which can be associated with transects placed near them.

Transect location and orientation will be random within particular soil types at particular contamination sources. Randomness of transect location will be insured by the use of random numbers to obtain compass bearings for transect direction. Transect locations within soil type and contamination source areas will be adjusted whenever necessary to avoid bare or severely distrubed areas, or to bypass areas thought to be unsafe.

The number of samples required is intended to incorporate vegetation sample data obtained by MKE in order to avoid duplication of effort and facilitate data exchange. Agreement has been reached between MKE and ESE for this effort. Additional site characterization data such as animal species present, abundance, and behavior will be obtained for all areas sampled.

Parameters to be measured on all vegetation transects include the number of individuals, cover (litter, bare ground, rock, plant species), height, and frequency. These measurements are useful for assessing vegetation changes due to the passage of time, change in location, or chemical treatments. In addition to these measurements, any signs of physiological abnormalities (etiolation, necrosis of leaves, stems, or roots, or chlorosis of leaves) will be noted for use in assessment of habitat injury. Observable phytotoxic differences between plants from contaminated and control areas will be considered significant above the 20 percent level (Cogley, et al., 1979, RIC#81266R08). If significant phytotoxic differences are observed, secondary testing will be done to test for factors other than phytotoxins that may be responsible for plant effects, such as soil character and condition, and water availability.

A previous survey of RMA for phytotoxic substances tested plant growth in soils from the major contamination sites (RIC#81341R02). Phytotoxins were identified in connection with the major contamination sites in Sections 26 and 36. A small amount of evidence was obtained for the presence of phytotoxins in Sections 9, 22, and 24, though the evidence appears to be limited to one site, and to be restricted to a narrow layer in the soil profile. Soil samples from Sections 5, 6, 8, and 23 appeared to be more or less free of phytotoxins (Torgeson and Sirois, 1976, RIC#81341R02). Historical information and recent soil and water studies indicate that control sites on RMA are uncontaminated.

3.1.3 FAUNA

Population data for key faunal species, part of a larger body of data gathered by MKE, will be used to help characterize experimental areas in terms of fauna. Additional population data will be collected by ESE for prairie dogs. Visual surveys will be conducted and presence noted. Census areas will be located throughout RMA to estimate total population levels in order to evaluate the prey base of important predators such as eagles. A literature review will be done to establish the normal range and variability in prairie dog populations. These animals will also be watched for signs of odd or unusual behavior.

Most of the site characterization data for faunal populations will be obtained from MKE and CDOW studies (Federal Aid reports), and from published literature. These will include data on carnivorous mammals, deer, rabbits, muskrats, raptors, pheasants, mourning doves, and song birds.

3.1.4 VOUCHER SPECIMENS

In accordance with 43 CFR Part 11.72 (k), a reference collection of floral and faunal specimens collected during assessment work will be submitted for expert identification. Expert taxonomic assistance will be provided by Dr. Janet Wingate (Denver Botanic Gardens) and Dr. James Halfpenny (University of Colorado, Boulder), as appropriate.

3.2 AVIAN REPRODUCTIVE SUCCESS

Toxic chemical effects on ducks and several other avian species inhabiting RMA have been observed since 1951 (Jensen, 1955, RIC#84292R04). Avian mortality has continued at RMA, although it has been at a lower level in recent years (McEwen and DeWeese, 1984; W. Adrian, 1986). Waterfowl mortality, before measures were taken to reduce exposure to toxicants, was estimated minimally at 20,000 birds over a 10-year period (Finley, 1959) and many other species of wildlife including birds, mammals, and amphibians died (U.S. Fish and Wildlife Service, 1961). In addition to the known direct losses of wildlife there are other important unanswered questions concerning toxic effects.

RMA is attractive to migrant birds because it is a large area of relatively undisturbed upland and wetland habitat in the midst of urbanized areas. However, the effects of organochlorine residues from RMA on resident and migratory birds remain unknown. It is not known whether these residues lower reproductive success, or cause mortality, as fat stores (where organochlorines concentrate) are metabolized.

In response to the concern about chemical contaminants in wildlife at RMA, Patuxent Wildlife Research Center initiated a 2-year study in 1982 of American kestrels as indicators of terrestrial contamination. This project was undertaken at the invitation of the Department of the Army. The U.S. Fish and Wildlife Service provided most of the funding for the work. The objectives of the kestrel study were to determine organochlorine chemical concentrations in kestrel eggs and young and to determine toxic chemical effects on kestrel reproduction.

In 1984, a limited survey of waterfowl nesting success at RMA was conducted by USFWS (McEwen and DeWeese, 1985). Fewer nests and broods of young were found than would be expected in the available habitat.

The results of both kestrel terrestrial bioindicators and waterfowl aquatic bioindicators signify continuing environmental contamination at RMA. Follow-up studies in 1986 and future years should establish whether there is a trend in dissipation and degradation of contaminants in these species. The objectives of avian reproductive success studies are:

- To measure avian breeding populations and reproductive success at RMA in comparison to the same species in similar uncontaminated wetland and terrestrial habitats;
- To measure concentrations of xenobiotic chemicals in eggs and young of the breeding species, particularly mallards, kestrels and pheasants.

Waterfowl nests will be searched for in all suitable habitat at RMA including the Lower Lakes, Rod and Gun Club Pond, and the North Bog areas. Standard survey procedures, including rope dragging, will be used. Pheasants will be sampled in suitable habitat in the vicinity of the Lower Lakes, within 1/2 mile of Basin F (outside fence), and portions of Sections 19, 20, and 29 in the northeastern corner of RMA. One egg will be collected for chemical analysis per nest and each nest will be marked for rechecking to determine the outcome of the remaining eggs.

Nest searches will be done within a 50 m strip of lake shoreline and in nearby areas of herbaceous vegetation. Nest density will be calculated per unit area of shoreline and per ha of herbaceous habitat for statistical tests.

Regular systematic waterfowl brood surveys will be conducted 2 to 3 times a week from June 1 through July 15, 1986 and weekly thereafter though August 31, 1986 to determine brood size and successful fledging. Collected eggs will be marked for identification and refrigerated in the field until processed in the laboratory at CSU. Egg weight, volume, dimensions, and shell thickness will be measured. The state of development of each egg will be recorded and the contents placed in chemically clean jars, weighted to 0.01 gram, and frozen until submitted to the specified ESE chemical laboratory. One young bird per each brood identified will also be collected (by gun, net, or trap) for necropsy and chemical analysis.

Similar waterfowl nest searches, brood surveys, egg collections and sample preparation will be done at a control area in Larimer County, Colorado. The control area for pheasant and waterfowl will be the

Wellington Wildlife Area, a 2,300 acre site with several lakes and ponds where human activity is restricted to prevent disturbance of waterfowl during nesting season. Other areas may be selected in order to obtain sufficient samples. Target sample sizes for collection of eggs and young will be 10 or more eggs and 8 or more young per waterfowl species per location (i.e., RMA and Wellington Control Area). Estimated numbers of egg samples are: 2 (mallard, ring-necked pheasant) species x 15 eggs (RMA) = 30, and 2 species x 10 eggs (control) = 20 for a total of 50 eggs. Numbers of young waterfowl collected will be fewer than the egg samples because of lower numbers available. Estimated numbers of prefledged birds of analysis are 2 species x 10 young x 2 sites = 40 total. Larger numbers of eggs and young birds will probably be available from control areas than from RMA, but sampling will be restricted to the minimum necessary for comparison with a breeding waterfowl at RMA.

Nest boxes for study of kestrel (sparrowhawk) reproduction from the earlier investigation are already in place at RMA and at a control site in Weld County, Colorado. Present utilization and productivity of birds using these boxes needs to be determined. One egg from each nest can be collected for chemical analysis and the hatchability of the remaining eggs, growth, and survival of young to fledging age can be determined. These data will serve as indicators of current terrestrial contamination at RMA.

Estimated kestrel sample sizes are 15 eggs and 8 young from RMA and 10 eggs and 8 young from the control area for a total of 41 samples. To reduce analytical costs, eggs could be composited into two samples per site. Young kestrels form RMA should be analyzed individually to provide data on variation in local terrestrial contamination there. Sample handling, storage, and procedures will be as described for the waterfowl. The areas of RMA where the nest boxes are located include all sections except Section 34. Several sections have only one or two nest boxes, usually near the edge of the section.

Samples of eggs and birds for contaminant analysis will be prepared and temporarily stored in the subcontractor's laboratory at CSU in accordance with approved sampling procedures. Samples will be delivered weekly to the ESE chemistry laboratory in Englewood, Colorado during each sampling period. ESE will be responsible for performing contaminant analyses and providing results to Dr. McEwen at least four weeks prior to the submission of the final report for this work.

3.3 TISSUE ANALYSIS FOR CONTAMINANTS

Analysis of biota for RMA contaminants will require the collection of plants and animals from sites of known or potential contamination on RMA, uncontaminated sites on RMA, and from offpost control areas. The selection of key species for analysis is based upon the following criteria:

- Listed as federally threatened or endangered;
- Important components of regional ecosystems (e.g., are abundant prey/predators);
- Are economically important (e.g., game or pest species); and
- Species which represent a trophic level or guild.

Contaminants for tissue analysis were determined on the basis of criteria which were consistent with current and proposed regulatory requirements (CERCLA, NRDA, etc.). Criteria included:

- Contaminants found in elevated levels in biota at RMA based on existing studies and found in the current RMA environment (soil, surface water, and ground water at a depth of less than 20 ft.);
- Contaminants on the basic inventory list of contaminants at RMA in the environment which are present in high volumes and/or with an areal extent of >5 acres;
- Chemicals which are considered moderately to highly toxic;
- Chemicals that would be expected to occur in biological tissues (many are either metabolized or exhaled without incorporation into tissues); and
- Chemicals for which occurrence/concentration in tissues could be related to any known adverse effects.

Cost effectiveness and reasonable cost were secondary considerations in the selection of species and chemicals for analysis.

The species list for contaminant analysis and suite of contaminants to be analyzed in each is based on current information for the major sites of contamination at RMA and for control sites on and offpost. Input for development of both lists was obtained during Biota Assessment Committee meetings from CDOW, Colorado Department of Health, Shell, MKE, and the U.S. Fish and Wildlife Service. Additional information from other environmental assessment tasks and data forthcoming from this assessment will provide data which may result in modification of this subtask (e.g., additional sites of contamination may be located).

Whole body analysis has been indicated for species which are prey for higher predators in order to determine the amount of contaminant which may be present in the food base for these predators. Carcass analysis will be done for species which are consumed by humans (e.g., cottontails) as well as by native predators.

The species, chemical contaminants, and tissues currently proposed for analysis are listed in Table 5.0-1 of the Letter Technical Plan in Appendix C. The number of samples per species may change, depending on the availability of adequate numbers/biomass from designated areas. Additional samples of chance (e.g., raptors and other predators) may be substituted, as available, into the analysis program. In most cases, the only organ analyzed will be liver, but some brain and kidney samples may also be tested. Detailed information on chemical certification and analysis are provided in Section 4.0.

3.4 CHOLINESTERASE INHIBITION

Chemicals such as organophosphorus and carbonate pesticides are known to inhibit cholinesterase enzymes (ChE) in wildlife species. Inhibition can result in disruption of nerve function and death of the organism. Brain cholinesterase inhibition studies also meet the acceptance criteria for determining biological responses for death injury under the proposed Natural Resource Damage Assessment (NRDA) regulations.

Brain cholinesterase inhibition testing will be conducted on organisms which are found dead in the vicinity of sites of complex contamination (e.g., Basin F) if the cause of death is not readily determined. This testing can be used to differentiate among contaminants which may be present in these systems and to better determine the chemicals implicated in the death of these organisms. This testing will be done in conjunction with tissue analyses for contaminants in order to meet the injury determination requirements under the proposed NRDA regulations.

Testing will be performed in the chemistry laboratory of ESE in Englewood, Colorado. Tissues for testing will be prepared and held in the supercold freezer at a temperature of less than 30°C prior to ChE analysis. It is anticipated that less than 100 samples will be collected and tested.

3.5 FOOD CHAIN DEFINITION

Preliminary contaminant pathways were determined in Phase I through the use of published literature on the general food habits of species and animal groups. Food habit studies are necessary in order to delineate actual contaminant pathways for species of concern at RMA. The results of food habit analyses will contribute to the identification and quantification of actual biological pathways through which potential contaminants have moved to the species being studied. The studies should reveal which foods (whether plant or animal) are being consumed by which animals, in what relative amounts.

Field methods will consist of two broad tasks:

- o Observe species in field to determine relative availability of utilized species; and
- o Collect stomach/crop content samples for comparison with observations.

Sample number will be determined by methods cited in Hanson and Graybill, (1956). Non-lethal sampling will be attempted for any species for which the taking of a "statistical" sample would be potentially decimating population-wise (e.g., mule deer).

Species for food chain studies will be chosen by use of at least the following criteria:

- o Species should be on the list of species to be sampled for tissue analysis, so that some connection can be made between body contaminant levels and ingested items. (Species on this tissue list will conform to guidelines outlined in 43 CFR, Part 11, p. 52161). Additional species for which contaminant data already exist may also be used;
- o Species should be fairly abundant and easy to collect; and
- o Relative position in food webs.

Species under consideration for use in food chain studies include the mule deer, ring-necked pheasant, mallard, and black-tailed prairie dog. These species are particularly important because of their documented contaminant accumulation tendencies, and because of their different relative positions in regional food webs.

3.6 INVERTEBRATE POPULATION STUDIES

Invertebrates constitute an important portion of the biota in ecosystems on RMA. Species groups were selected for investigation because of their role as herbivores, as prey for key species (Section 2.4.1.4) and because of their potential for demonstrating direct injury from RMA contaminants.

Earthworms can be used as a direct measure of biotic injury or as indicators of injury to soils under the NRDA regulations. This group is also important as a food source for terrestrial organisms. Population and contaminant studies are important for evaluating soil injury, verifying contaminant pathways, and providing an objective basis for determining injury to soil biota.

Grasshoppers are abundant terrestrial invertebrates that constitute a substantial portion of diet of many animals, including immature pheasants. Population/biomass sampling of this group will provide quantitative data on the invertebrate primary consumer level in relation to key predator species. Contaminants have been documented in grasshoppers from RMA (see Section 2.0). Knowledge of contaminant levels

in this group can be related to pathways determination, possible bioaccumulation, and injury effects on higher order consumers such as pheasants.

Aquatic snails are a major item in the diet of aquatic and semi-aquatic organisms including game fish and waterfowl. Relatively high contaminant levels have been found from the 1960's through the 1980's in aquatic snails from the lower lakes on RMA (MF# RFA 003 0659; MF# RSH 855 1544; MF# RMA 076 0736). Snails are particularly important in the diet of waterfowl during nesting season and provide protein and a source of calcium for eggshell production. Determination of population size and contaminant levels is important for pathways confirmation and potential injury determination is aquatic ecosystems.

3.6.1 EARTHWORMS

Ten randomly selected sampling points will be selected within identified sites of contamination, uncontaminated sites onpost (onpost control areas), and in offpost control areas. Some subsampling within contaminated sites (e.g., Basin A) may occur. Sites of contamination which will be sampled include Basins A, C, D, and E and the South Plants Area based on the concentration and distribution of contaminants in the soil.

Earthworm population densities and biomass will be determined by physical excavation of known soil volumes and subsequent hand sorting and removal of worms (Walter and Snider, 1984). Soil samples will be excavated during the same season (late summer and early fall), general weather conditions, and at the same time of day. Areas of soil compaction or recent evidence of surface disturbance will be avoided in selecting random sampling locations.

Each sample will be obtained by excavating a soil (1 m^2 by approximately 15 cm deep)(Walter and Snider, 1984). A frame will be used to define the surface area, and the plug excavated using a spade. The soil will be sorted and the earthworms removed. The soil will then be returned to its original location following sorting. Soil moisture and soil temperature

will be recorded for each sample area. Sampling in areas of potential contamination will be conducted using appropriate protective clothing and under the supervision of site safety personnel (Section 7.0).

A pilot study will be conducted on RMA prior to implementation of the program in order to determine if changes in sampling techniques, sample size, or type of data recorded are needed. The pilot study should be completed and a report prepared indicating any modifications prior to actual sampling.

To minimize heat stress, field sampling will be conducted during early morning hours (0530 - 0930 hours) in September. A population count and total wet weight of earthworms will be obtained for each sample. A subsample of worms will be retained for identification and voucher purposes. Samples of worms for chemical analysis will be composited from worms collected in the course of population surveys. Control sites will be selected on the basis of similar soil type (using types described by the SCS county soils reports), vegetation cover, and land use history.

3.6.2 GRASSHOPPERS

Grasshopper abundance will be estimated using a standard ocular technique (D. Thompson, 1986). This method is recommended for grassland habitats because it provides a more precise estimate of the area surveyed than sweep netting techniques and because small plots permit accurate counting of grasshoppers.

Plots of 0.1 square meters will be established at 10 m intervals along 100 m transects randomly located in contamination sites and in on and offpost control areas. Ten points will be established along each transect, and five transects will be sampled at each site. Subsites (e.g., smaller areas of contamination with larger sites) will be surveyed with fewer transects. The plot will be defined by circular plots placed along transects in the field at least two hours before the survey is conducted in order to allow grasshoppers dispersed by plot placement to return to the area. Vegetation height, density, dominant species composition will be recorded as will air temperature, general weather

conditions, date, and time of sampling. Sampling will be done during mid summer (July and August) 1986. Grasshoppers collected for contaminant analysis will come from the areas surveyed for population density and will be collected with a sweep net following the last field survey.

Transects which meet the following conditions will be randomly selected within each sample area:

- All points on each transect will be at least 10 m from the nearest defined boundary and no closer than 10 m to the nearest transect;
- Transects will be located by using a grid overlay to select one point, then orienting the transect toward (or through) the nearest survey grid marker; and
- Transects will not include or traverse areas of disturbed and/or compacted ground.

Each transect will be marked at each end with wooden stakes so that the same transects and plots can be surveyed during each of the three survey periods. Sampling will be conducted under generally favorable weather conditions (wind less than 10 mph, no precipitation). Sampling will be coordinated with other sampling activities to avoid periods of disturbance during survey.

3.6.3 AQUATIC SNAILS

Ten samples will be collected from each of the lower lakes on RMA (Lower Derby, Ladora, Mary), Gun Club Pond, and from the North Bog. Equal numbers of samples will be collected from two offpost control areas at Wellington State Wildlife Area.

Sample design includes:

- Determining the perimeter of each body of water;
- Randomly selecting distances about each lake; and
- Randomly selecting distance from shore/heavy vegetation (up to 20 ft maximum) in which to sample (sample point should not exceed an 18-in water depth for this study).

A 1 m^2 sample frame will be placed at each sampling point and a $\frac{1}{4}$ m^2 sample plot will be randomly sampled for snails. Water temperature, average depth, pH, and type of substrate (e.g., aquatic plants present or absent) will be recorded for each sample location. All snails and vegetation within the plot will be collected. All vegetation will be weighed for each sample at the ESE laboratory. Snails will be counted and weighed from each sample. All specimens will be preserved in 10 percent formalin and saved for subsequent identification.

A pilot study will be conducted to determine if modifications to this sampling technique are necessary. The study will be completed and a report containing any suggested changes will be filed prior to implementation of field sampling. Sampling in sites of potential contamination will require the use of appropriate safety gear and procedures.

3.7 PHYSICAL MALFORMATIONS

Physical deformation is generally defined as alteration in shape, size, and/or structure of an organism or any part of an organism (U.S. Department of Interior, 1986). Deformaties attributable to chemical contaminants have been reported in embryos, nestlings, and adult birds in the field. Gilberton and Fox (1977) recorded over external deformations related to organochlorine exposure.

Although physical deformations of birds have not been documented from RMA in relation to sites of organochlorine contamination, physical deformation of toads has been noted in Basin D correlated with dieldrin in the tissues of these animals (U.S. Army Dugway Proving Ground, 1973, RIC#84131R02). The areal extent, concentration, persistence, and known biological effects of organochlorine pesticides including aldrin, dieldrin, and endrin on RMA suggest that substantial injury in the form of physical deformation may have occurred and may still be occurring at RMA.

Although other biological responses (e.g., skeletal deformaties, histophathological lesions, internal organ malformations) may also occur,

methods of observation and documentation require the sacrifice of large numbers of individuals which would be both unjustifiably expensive and would inflict substantial damage on the animal populations being studied. Observations of physical deformities in connection with the presence of organochlorine compounds meets the criteria of acceptance for documentation of injury to biological resources (43 CFR Part 11: 11.62 (f) (2)). The studies proposed herein would be conducted in conjunction with avian reproductive sampling, would require little additional time for recording observations, and would therefore involve only minor increased costs.

Hatchling and immature birds observed at nests during avian reproductive success studies would be examined for evidence of overt external deformities such as crossed bill, small eyes, reduced mandibles, and foot malformations. Nests would be checked frequently during incubation so that any seriously deformed young, not likely to survive could be noted before these individuals expired and were lost from the population. It is anticipated that these observations would require a minimum of two visits to each nest during the period of late incubation and early hatching for each of the three major bird species; ringneck pheasant, mallard, and American kestrel.

Although other bird species would be observed and deformities noted in the course of avian reproductive success studies, it is not anticipated that deformities in other species would be documented in sufficient numbers to detect statistical differences between contaminant and designated control areas on a per species basis. The frequency of occurrence of overt physical deformities of hatchling and immature birds would be compared between areas of contamination and designated control areas using appropriate parametric and/or nonparametric statistical procedures (Sokal and Rohlf, 1981).

3.8 CRITERIA DEVELOPMENT

Key chemicals of concern to biota will be identified using all available information on the distribution and concentration of RMA contaminants in the abiotic environment and on the hazard potential of these chemical

contaminants. Hazard assessment criteria used to evaluate these chemicals will include octanol-water and carbon-water partition coefficients, water soluability, depuration rates, metobolism/degradation information, bioconcentration potential, and toxicity information. Both lethal and sublethal effects and contaminant levels in biota and the environment to which biota are exposed will be evaluated. Biota will be assessed from three aspects of consideration:

- Protected and regulated species (e.g., bald eagles);
- Species which are important components in the structure and function of regional ecosystems (e.g., black-tailed prairie dogs); and
- Species which might serve as pathways of contaminant transfer to humans (e.g., deer, ducks, cottontails, pheasants).

This information will be assessed in conjunction with task involvement in Task 35 (EA) and the U.S. Army Medical Bioengineering Research and Development Laboratory. Pathways analysis will be used to evaluate the potential for harm to selected species, regional ecosystems, and humans as described above. Pathways information will develop in conjunction with food web studies and with the endangerment assessment tasks conducted for RMA and the offpost area. This activity will continue throughout the development of the biota assessment for the RI and will add/delete species and chemicals based on the acquisition and evaluation of new information.

3.9 DOMESTICATED PLANTS AND ANIMALS

Records from RMA, data from growers and vendors in the offpost study area, surveys of well records, and interviews with residents in the offpost study area indicate a potential for contamination of domesticated animals and crops offpost. Potential contamination effects include injury to the biota and implication of contaminated plants and animals as a contamination pathways to humans. References to domestic animal and crop injury are present in records from the 1950s. Regulatory requirements and the need for pertinent data on biota effects indicate the need for investigating this topic.

This subtask will consist of examination of available information on the distribution and concentration of RMA contaminants in the environment inhabited by domestic biota off of RMA and will be performed in conjunction with the offpost endangerment assessment. Surface water contamination near RMA and contaminated ground water which is used for irrigating domestic crops and/or watering livestock will be determined. Areas and resources affected (e.g., crops, cattle, sheep, etc.) will be determined from existing information.

Investigations will result in a summary of the potential for detecting offpost contamination in biota. This information will be used as a basis for determining if offpost sampling and/or surveys are needed to determine the natural and extent of potential injury and/or risk involving domesticated biota.

3.10 SAMPLING AND ANALYSIS SCHEDULE

The tentative schedule for field sampling and chemical analysis is presented in Figure 3.10-1. Additional seasonal sampling and chemical analysis for domesticated plants and animals and implementation of a Habitat Evaluation Procedures (HEP) program may occur as the result of information acquired during the Phase II studies described in this technical plan. Some slippage is anticipated due to uncertainties in the develoment of certified analytical procedures for biological media; ongoing discussions with MOA parties (regarding chemicals, areas, and species of concern); and the availability of new data on the presence, distribution, and concentration of RMA contaminants in soil, water, and air.

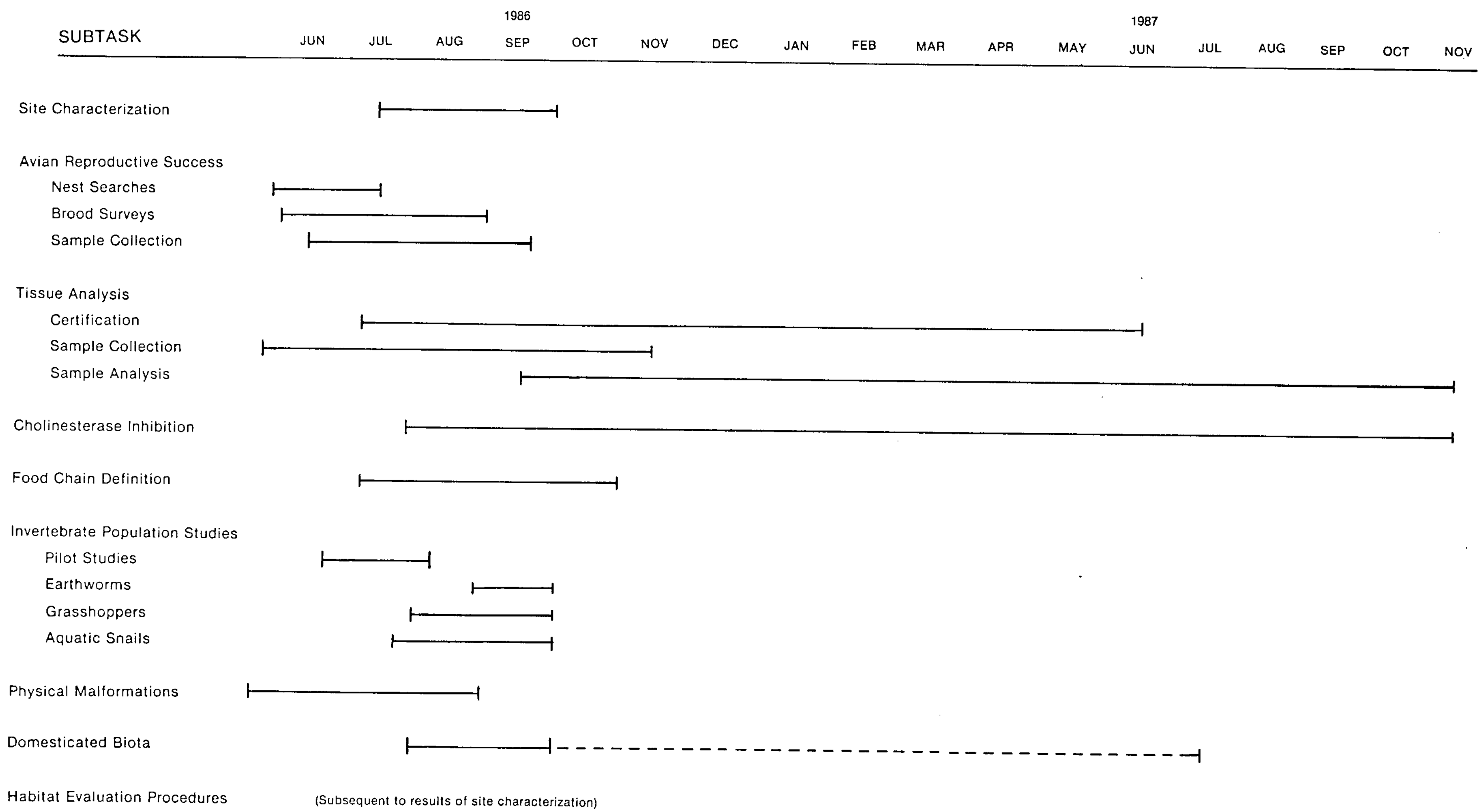


Figure 3.10-1
BIOTA ASSESSMENT PHASE II FIELD SAMPLING AND CHEMICAL ANALYSIS SCHEDULE
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

4.0 CHEMICAL ANALYSIS

The objectives of the laboratory analysis program will be to provide reliable, statistically supportable, and legally defensible chemical data regarding contamination in biological tissues at RMA. The defensibility and technical quality of the data are assured by requiring documentation of all sample and extract transfers (Figures 4.0-1 and 4.0-2) and following analytically sound methodologies for all contaminants addressed. ESE's approach in applying the USATHAMA 1985 Quality Assurance (QA)/Quality Control (QC) plan is summarized in Section 5.0 and will be fully developed in the project quality assurance program. This program includes the analysis of sample duplicates (at 10% frequency), laboratory method blanks, and National Bureau of Standards (NBS) animal and plant tissues spiked at specified levels.

Chemical analysis will be performed on selected animal and plant tissues for organochlorine pesticides (aldrin, dieldrin, endrin), mercury, and arsenic. Additional compounds (such as DDE and DDT) can be added to the program following certification and authorization from the PMO-RMA. Samples will be animal whole body/carcass, animal organ, and plant tissue, dependent upon the scope as outlined in the technical approach for the Biota program. Samples will be processed and batched according to matrix and analyzed on instrumentation dedicated to that particular sample type.

4.1 LABORATORY CERTIFICATION

ESE currently holds USATHAMA certifications for the analysis of the organic and inorganic compounds designated for this program (Table 4.1-1). Additional compounds (if needed) will be certified under the 1985 USATHAMA QA Plan. The procedure for certification is outlined in detail in the QA Plan but in general requires the following steps:

- Establish the Target Reporting Limits (TRL's). The TRL's typically represent the lowest instrumentally measureable concentration and are targeted at levels below local, state, or federal criteria whenever technically achievable. These limits are usually specified by USATHAMA.

Project Name: ____________________ Project Number: ____________

Analytical Method: ________________ Lot/Batch: ____________

Sample No.	Collection Date	Sample No.	Collection Date	Sample No.	Collection Date

Date Relinquished	From	To

Figure 4.0-1
ESE-DENVER INTERNAL CHAIN-OF-CUSTODY
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Project Name: ____________________ Project Number: ____________________

Analytical Method: ____________________ Lot/Batch: ____________________

Sample No.	Extract/Digest Date	Extractor	Date Relinquished	From	To	Date Relinquished	From	To

Figure 4.0-2
SAMPLE EXTRACTION/DIGESTION TRANSFER SHEET
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

Table 4.1-1. ESE-Denver USATHAMA Certified Methods

Analyte	USATHAMA Method Code	Certified Reporting Limits*	
		LCR	UCR
Arsenic-Animal and Plant	B6	0.25	5.0
Mercury-Animal and Plant	C6	0.050	0.40
Pesticides-Plant	D6		
Aldrin		0.022	0.300
Dieldrin		0.044	0.300
Endrin		0.040	0.600
Pesticides-Animal	E6		
Aldrin		0.020	0.300
Dieldrin		0.031	0.300
Endrin		0.040	0.600

* Certified Reporting Limits (CRL's) as estblished by method certification. Reported in µg/gram.
LCR = Lower Certified Range
UCR = Upper Certified Range

- Submit a proposed method development plan. This plan describes the technical approach to the method and includes details on procedures and instrumentation. The plan will propose the TRL's, the tested concentration range, and the certification class to be performed.

- Submit a Precertification Performance Data Package. Prior to method certification, calibration curves for each of the target analytes will be prepared and analyzed in duplicate. These calibration curves will bracket the tested concentration ranges and will correspond to approximately blank, 0.5, 1, 2, 5, and 10 times the TRL (Class 1). The curves will be evaluated for Lack of Fit (LOF) and Zero Intercept (ZI) according to the USATHAMA software program supplied. Non-linear calibrations (quadratic or cubic) will be investigated and justified prior to submittal for acceptance.

- Submit a Certification Performance Data Package. The actual method certification will consist of spiking samples of NBS bovine liver or plant tissue (tomato or citrus leaves) with analytes of interest at 0, 0.5, 1, 2, 5, and 10 times the TRL. The spiking and analyses are repeated on 4 consecutive days to complete the Class 1 certification. The target versus found data obtained from the 4 days are entered on the USATHAMA software to provide LOF, CRL's, accuracy, and precision for the method.

The certification packet, upon approval by USATHAMA, is the certified method to be used for routine laboratory analysis. This comprehensive document describes the method in detail and lists the standard operating procedures (SOP's) for daily operation.

4.2 SAMPLE PREPARATION, CONTAINERS, AND HOLDING TIMES

Samples received from the field by the sample custodian are logged into the laboratory data system and placed in a freezer maintained at -80°C until time for sample preparation. Whole animal samples too large for

standard glass containers are wrapped in two layers of hexane rinsed aluminum foil for storage. Egg, small animal, animal organ, and plant tissues are placed in acid and hexane washed glass containers suitable for cryogenic storage. When preparation is scheduled, samples are removed and transferred to technicians/analysts with appropriate chain-of-custody forms. Samples requiring sectioning are so processed by cutting into one-inch squares using a reciprocating band saw. Twenty-five gram aliquots of the samples are placed into blenders along with equal quantities of dry ice and homogenized for five minutes. The homogenized samples are placed in a refrigerator (@ 4 C) until the dry ice has sublimed off and the samples have come to constant weight. Aliquots of the homogenized sample are taken as follows:

Analysis	Sample Required (g)	Aliquot Amount (g)
Arsenic	1	2
Mercury	1	2
Pesticides	8	10

Additional material, if available, along with the separate aliquots are labeled and returned to the freezer for storage until analysis. Samples and homogenates can be held for up to 2 years (freezer temperature less than -30°C) prior to analysis. Figure 4.2-1 is a diagram of the sample and extract flow controls and shows where chain-of-custody transferral occurs.

4.3 ANALYTICAL METHODS

Homogenate samples for pesticides and metals will be prepared simultaneously by the sample preparation group and maintained at -80°C. Samples for analysis will be batched for maximum efficiency and scheduled according to available instrument and analyst's time. Batch size will be approximately 10 samples for pesticides, 20 samples for mercury, and 30 samples for arsenic.

Standard reference materials obtained from NBS will be used for matrix spike recovery data (QC spikes). Bovine liver (SRM 1577A) will be used for animal daily control spike of pesticides and metals. Tomato leaves

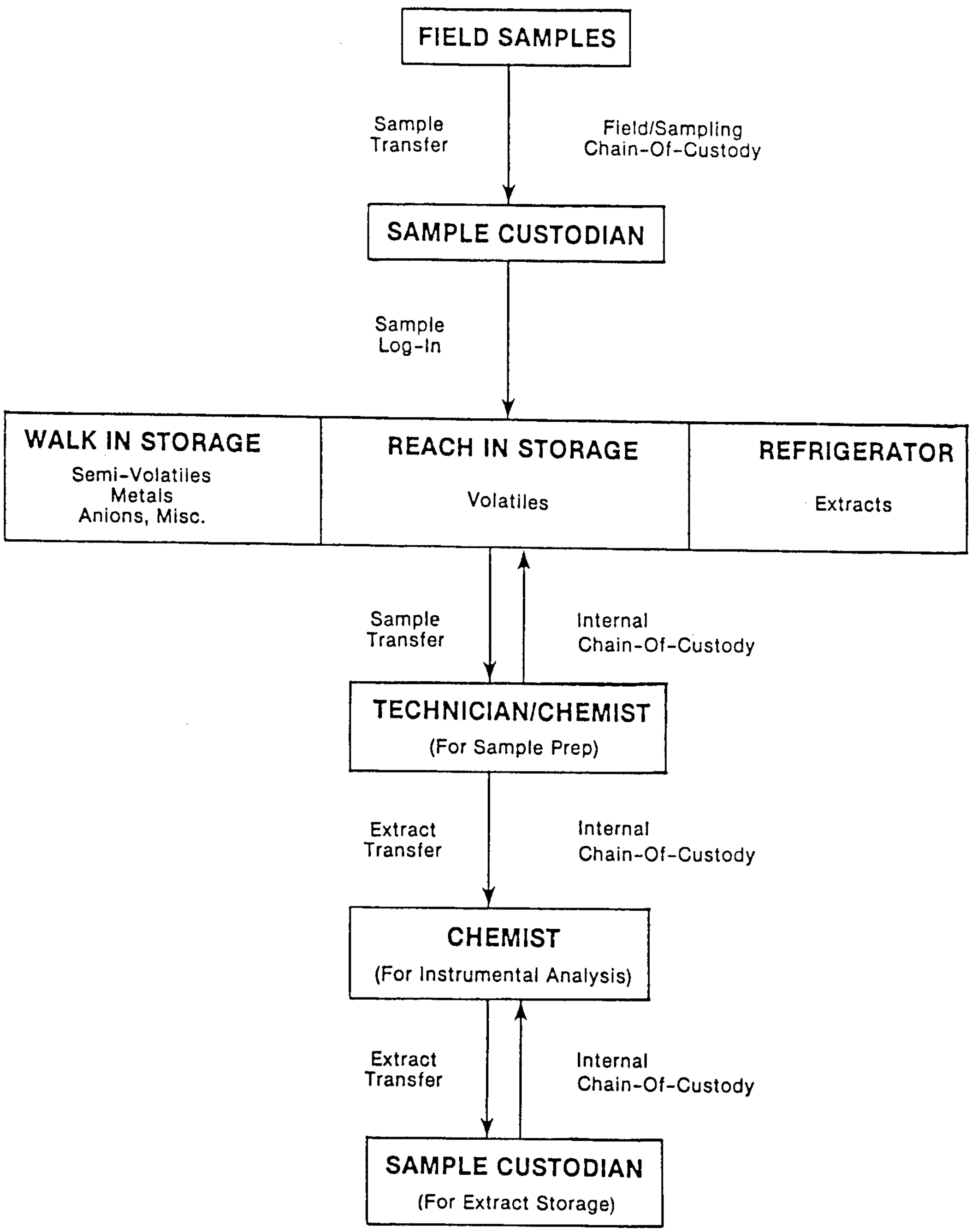


Figure 4.2-1
SAMPLE AND EXTRACT FLOW CONTROLS
SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

(SRM 1573) are to be spiked for metal recoveries; however, due to background levels of pesticides present, they cannot be used for organic analysis. Citrus leaves (SRM 1572) will be used as the "standard plant tissue" for pesticide analysis.

4.3.1 ARSENIC ANALYSIS

One gram of homogenized, thawed sample is digested in concentrated nitric acid and 30 percent hydrogen peroxide. The digestate is filtered, taken to volume, and analyzed for arsenic by graphite furnace atomic absorption spectroscopy (GFAA). General instrument and calibration conditions are described in "Methods For Chemical Analysis Of Water And Wastes" (EPA, 1983), Method 206.2.

4.3.2 MERCURY ANALYSIS

One gram of prepared sample is digested in concentrated sulfuric and nitric acids for thirty minutes at 95°C. the digestate is allowed to cool, potassium permanganate and potassium presulfate are added to further oxidize organic forms of mercury, and the sample is placed on a "hot-block" digestor for an additional 30 minutes. Volumes are readjusted and the sample analyzed for mercury by cold vapor atomic adsorption spectroscopy (CVAA). Reagents and operating parameters for the mercury determination are described in the Instrumentation Laboratories' S12 and AVA-440 Operations Manual.

4.3.3 ORGANOCHLORINE PESTICIDE ANALYSES

Eight grams of sample are placed in an extraction thimble along with 20 grams of anhydrous sodium sulfate, spiked with 0.1 mL of 40 µg/l p,p'-dichlorobenzophenone surrogate (22DCBZ), and allowed to equilibrate for one hour. The thimble is soxhlet extracted with pesticide grade hexane for 4 hours at a nominal cycling rate of 6 cycles per hour. A 15 ml aliquot of the extract is saponified with alcoholic potassium hydroxide, concentrated, and passed through florisil to remove matrix interferences. The final extract is analyzed by gas chromatography using an electron capture detector and a DB-17 capillary column. Positive results for pesticides are qualitatively confirmed by retention time indices on an alternate DB-5 analytical column. Analytical conditions and instrument

calibrations are derived from routine methods established by the EPA(Method 608 - Organochlorine Pesticides and PCB's, 40 CFR Part 136, Appendix A) and methods developed by the U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center.

5.0 QUALITY ASSURANCE

5.1 FIELD LABORATORY QA PROGRAM

A necessary and integral part of the Technical Plan for RMA is the project-specific QA Plan describing the application of ESE procedures to control and monitor USATHAMA sampling and analysis efforts. ESE has developed a Field Laboratory QA Plan applicable to the sampling and analysis activities on RMA. This plan is based on USATHAMA December 1985 QA Program requirements and complies with ESE policy.

The ESE Western Regional laboratory will perform all biota analyses for samples from RMA. ESE Western Regional laboratory will comply with the ESE Field Laboratory QA Plan. A Laboratory QA Coordinator has been appointed to the laboratory to monitor compliance with the QA Plan and perform the QA duties in that laboratory. The laboratory QA coordinator will be responsible to the RMA Project QA Supervisor for performance of the required QA/QC activities in the Western Regional laboratory.

The Field Laboratory QA Plan has been employed to ensure the production of valid, properly formatted data defining the precision, accuracy, and sensitivity of each method used for USATHAMA sampling and analysis efforts. Specific RMA QA/QC requirements are described in the following sections.

5.2 SPECIFIC RMA REQUIREMENTS

5.2.1 FIELD PROCEDURES

The Field QC Monitor for the ESE field sampling efforts has been appointed with the responsibility of assuring compliance with the QA/QC Plan. The Field QC Monitor will report any discrepancies that cannot be resolved onsite to the Project QA Supervisor. Field sampling QA audits of the biota sampling procedures for RMA will be conducted by the Project QA Supervisor or QA Coordinator every 6 to 8 weeks. Samples must be collected in properly cleaned containers, promptly and properly preserved, and transported to the laboratory. The ESE Field Laboratory QA Plan describes the procedures to monitor adherence to approved sampling QC procedures.

Field operations to be audited include: (1) sample handling; (2) use of sample containers for the particular analysis; (3) use of approved sampling techniques; and (4) field documentation and chain-of-custody documentation. During subsequent laboratory audits, the QA Coordinator will monitor sample container preparation. A Field Sampling Audit Checklist will be completed, and a QA Field Audit Report will be submitted to the Project Manager within 30 days of the QA field audit trip. Any procedures not complying with USATHAMA and ESE sampling QC practices will be identified to the Project Manager within 24 hours of observation, and he will insure that proper corrective actions will be taken.

5.2.2 SAMPLE PREPARATION AND BATCHING

The Project QA Supervisor or designee will monitor the sample preparation procedures including sample container preparation to assure compliance with USATHAMA requirements.

The Laboratory QA Coordinator will be responsible for the establishment of Army lots after the samples have been logged into the laboratory. Samples have been batched into groups of approximately 6 to 7 samples per lot for the pesticides, and 14 to 16 per lot for metals. The size of the lot will depend on the particular chemical analysis to be performed and the rate of sampling and chemical analysis. The field sampling effort rate and shipment of samples have been coordinated to ensure that the laboratory capacity and optimum lot sizes are met.

Blank samples of a "standard" matrix must be analyzed along with each lot for all analytes. When the concentrations of target analytes are greater than the upper limit of the certified range of a particular analytical method, the sample extracts are typically diluted to within the certified ranges and reanalyzed. All data will be corrected for dilution factors and spike recovery at certification.

The Laboratory QA Coordinator will also be responsible for assigning the QC Control Spike Samples for each lot and monitor the sample analysis to assure compliance with USATHAMA requirements.

5.2.3 HOLDING TIMES

Holding time requirements for the RMA sampling effort are outlined in Table 5.2-1. The Laboratory QA Coordinator will monitor the chemical analysis and sampling effort to assure compliance with USATHAMA holding time and preservation requirements. Any problems that have been identified by the Project QA Supervisor will be relayed to the Project Manager, and appropriate corrective action will be instituted.

Because of litigation requirements, no holding time exceptions will be granted. If holding times are exceeded or the lab anticipates exceeding holding times, the Project Manager and Project QA Supervisor will be contacted. Samples which have exceeded the holding times will not be analyzed.

5.2.4 DETECTION LIMITS, ACCURACY, PRECISION, AND CERTIFICATION

The certification status and analytical methods to be used for the analysis of biota samples from RMA are given in Table 5.2-2. All analytical methods have been certified using "standard" matrices from the NBS. All methods have been certified as described in Section 4.0 of the Task Number 1 Technical Plan (ESE, 1985, RIC#85127R07), over as large a linear range as possible.

5.2.5 ANALYTICAL CONTROLS

Daily QC of the analytical systems ensure accurate and reproducible results. Careful calibration and the introduction of control samples (control spikes and blanks) are prerequisites for defining the accuracy and precision of the sample results. Instrumental and sample lot controls are described in Section 4.7 and the approved certified method write-ups.

The Laboratory Coordinator will monitor the analytical controls. Failure to pass the instrumental calibration or control sample QC criteria represents an out-of-control situation. Written notification of the QC failure will be provided to the Project Manger, and proper corrective action will be implemented by the Project QA Supervisor.

Table 5.2-1. Holding Times for Biota Samples

Analyte	Storage Holding Time	Extraction Holding Time
Pesticides	2 years	40 days
Metals	2 years	6 months

Table 5.2-2. Biota Method Detection Limits and Certification Status

Analytes	Certification Status	Certified Reporting Limits
As in Biota	Certified Feb. 18, 1987 (USATHAMA Method B-6)	0.2-5.0 µg/g
Hg in Biota	Certified Feb.22, 1987 (USATHAMA Method C-6)	0.05-0.40 µg/g
Pesticides in Animal Tissue	Certified Apr. 1, 1987 (USATHAMA Method E-6)	Aldrin - 0.020-0.300 µg/g Dieldrin - 0.031-0.300 µg/g Endrin - 0.040-0.600 µg/g
Pesticides in Plant Tissue	Certified Mar. 18, 1987 (USATHAMA Method D-6)	Aldrin - 0.022-0.300 µg/g Dieldrin - 0.044-0.300 µg/g Endrin - 0.040-0.600 µg/g

5.2.6 REVIEWING AND REPORTING REQUIREMENTS

The Chemical Analysis Supervisors and the Laboratory QA Supervisor or Coordinators at the ESE laboratories are responsible for reviewing and approving analytical data generated in the laboratories prior to transmittal of data to USATHAMA. Using the standard computerized data management system in each laboratory, automatic quality control checks will be made on the data from each lot of samples processed. In addition, manual QC checks have been performed by the Chemical Analysis Supervisor and Laboratory QA Supervisor or Coordinator in each laboratory.

The laboratory will maintain a chemical data file for each lot of samples analyzed which will include: (1) copies of logsheets of sample receipt; (2) extraction logsheets; (3) instrumental logsheets; and (4) raw data sheets including complete chromatograms, calibration curve data, calculation worksheets, and final data.

Control charts will be maintained for each analysis conducted by the laboratory. The control charts will be reviewed by the Laboratory QA Coordinator and submitted to USATHAMA, weekly. Upon generation of a data report in USATHAMA IR-DMS format for each field group of samples, a portion of the data will be validated by the Laboratory QA Supervisor or Coordinator in each of the respective laboratories. The amount of data validated have been selected according to procedures specified in "Sampling and Procedures and Table for Inspection of Attributes, Military Standard" (MIL STD-105D, April 29, 1963). Validation involves tracking of a final data point through calculations and back to the raw data to verify the reported value and assure the presence of the required data documentation. Data deficiencies discovered during validation will be reported to the Chemical Analysis Supervisor for corrective action.

Section 6.0 of the Task Number 1 Technical Plan, Appendix B details the reviewing and reporting functions of the Project QA Supervisor. A formal review and sign-off sheet will accompany all chemical analysis results for each completed Army lot of samples. It is the responsibility of the

Laboratory QA Supervisor or Coordinator to check the sign-off sheet periodically to ensure that the review process is complete.

During the active conduct of chemical analyses, the Laboratory QA Supervisor or Coordinator will submit a QA Program status report upon completion of each analytical lot to USATHAMA. This submittal will include a hard copy of the lot QC charts. All points which indicate an out-of-control situation will be evaluated and explained and necessary corrective action to prevent recurrence described.

6.0 DATA MANAGEMENT PLAN

Data for Task 9 will be handled according to the Data Management Plan in Volume I of the Task 1 Technical Plan Contract Number DAAK11-84-D-0016. Sample number assignments, labels, and logsheets will be made in Gainesville and given to the sampling team. Samples shipped to laboratories will follow chain-of-custody procedures described in the Technical Plan. Figure 6.0-1 is an overview of the Data Management procedures for PMO-RMA/USATHAMA analysis.

A map record, field sample monitoring record, and chemical record data file will be created for each subtask. Environmental sampling parameters will be defined and modified according to the requirements of each sampling program. Field data will be entered into the microcomputer LAN system at the ESE Denver office and transmitted to the ESE Gainesville office via telephone. The field data will be transferred to the IR-DMS, put through the data check routine, validated, and put in Level 2. (Data cleared for Level 2 has been approved for use by other contractors).

Samples shipped to laboratories will follow chain-of-custody procedures described in the Technical Plan. Data from lab analyses will be entered into the ESE Prime 750 computer, incorporated with certification and field data, and formatted into files according to the IR-DMS User's Guide. After validation these files will be sent to the Univac using the Tektronix or the microcomputer LAN system, run through the data check routine, and elevated to Level 2.

Data Management Supervisor Responsibilities

The Data Management Supervisor is responsible for coordinating transmission of all completed data coding forms to PMO-RMA/USATHAMA. The Supervisor's specific responsibilities include:

- Supervise the operation of the ESE data management system;
- Incorporate QC and IR-DMS requirements into the ESE chemical data management system;
- Incorporate onsite meteorological data;

- Review all completed field data coding forms for compliance with IR-DMA requirements;
- Instruct laboratory and field personnel in the proper procedures for recording data;
- Transmit approved Level 1 data on a regular scheduled basis to the PMO-RMA/USATHAMA IR-DMS;
- Transfer Level 1 data to Level 2, after approval/validation; and
- Delete obsolete Level 1 files in accordance with PMO-RMA policy.

To fulfill his/her responsibility to transmit all completed data in IR-DMS upon Site Manager approval, the authorities of the Data Management Supervisor are to:

- Approve or disapprove of laboratory or field data with regard to formatting, as required by the project Data Management Plan.
- Directly communicate with PMO-RMA/USATHAMA data management personnel with regard to data transmittal problem resolution.

7.0 SAFETY PROGRAM

The purpose of this section is to summarize the safety, accident, and fire protection standards and to outline standard operating procedures to ensure the safety of all ESE personnel and its subcontractors performing Task 9 activities. Responsibilities, authorities, and reporting emergency procedures as designated to Task 9 are identical to those designed for Task 1 in Section 7.0 of the Task 1 Technical Plan.

This program addresses all of the requirements of DI-A-5239B and fully complies with requirements of the Occupational Safety and Health Administration (OSHA) and the U.S. Army Material Command (AMC) Regulations 385-100, Army Regulations (AR) 385-10, and Department of Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

7.1 GENERAL SAFETY PROCEDURES

7.1.1 HOTLINE SYSTEMS

Hotlines extend around Section 36, as noted in the Task 1 Technical Plan, Basins C, D, E, and F, and source areas in Sections 19, 20, 22, 23, 24, 25, 27, 28, 29, 30, 31, and 35. Hotlines in the southern half of RMA, mainly those areas south of December 7th Avenue have been established by EBASCO. Work in the southern half of RMA will require the Onsite Safety Officer (OSO) or the field team to consult EBASCO and discuss areas that require personal protection or extra safety precautions. It is not anticipated that any biota work in the southern half of RMA will require an upgrade from Level D to a higher level of protection.

7.1.2 LEVELS OF PERSONAL PROTECTION

Levels of personal protection will be task specific. Personnel will wear a specific level of protection appropriate to the area in which their activities take place. Section 7.2 describes levels of protection and specific procedures for each activity.

7.2 ACTIVITY SPECIFIC SAFETY

All field crews will be made up of at least two people whenever working in hazardous areas. All crews will carry a radio so that they can be in constant communication with the base station. The field crews will also notify the fire department and emergency personnel as to where they will be working each day. The following section describes safety procedures to be followed for each specific activity taking place under Task 9.

7.2.1 SITE CHARACTERIZATION

Site characterization will take place in Section 36, the Lower Lakes area, South Plants area, and outside the fence at Basin F. Personal protection in Section 36 will consist of modified Level D clothing. This level of protection includes: Tyvek® coveralls, steel toe and shank rubber boots, latex rubber boot covers, 2 pairs of chemical resistant gloves, a full face air purifying respirator, and an escape pack respirator. Respiratory protection will not be required to be worn unless there is airborne visible dust. All decontamination procedures will follow those set forth in the Task 1 Technical Plan.

Activities in the Lower Lakes area, South Plants area, and outside of Basin F will require Level D protection. Steel toe and shank rubber boots, and gloves will be worn by field personnel. If activities require entering the water in the Lower Lakes area, field personnel will don hip waders. A safety rope will also be employed with one person onshore in the event that the person in the water falls or steps unknowingly into a hole or deeper water.

Because of the contaminated sediments in the Lower Lakes, hip waders will need decontamination upon leaving the water. This will be accomplished using two metal wash tubs, an Indian sprayer, and a scrub brush. Waste water will be disposed of at the Section 36 wash pad.

7.2.2 AVIAN REPRODUCTIVE SUCCESS

Avian reproductive success investigations will take place in the Lower Lakes area and in the Basin F area outside the fence. Personal protection will be identical to that described in 7.2.1 for these areas.

7.2.3 TISSUE ANALYSIS FOR CONTAMINANTS

Tissue analysis will require the collection of biota in Section 36, Basin F and its surrounding area, and the Lower Lakes area. Personal protection for work in Section 36 and the Lower Lakes is described in Section 7.3.1. If this activity requires entering Basin F, this will be done wearing Level B protection. This protection consists of a self-contained breathing apparatus (SCBA), Saranex® coveralls, rubber boots with steel toe and shank, two pairs of latex rubber boot covers, and two paris of chemical resistant gloves.

Decontamination procedures for Section 36 and the Lower Lakes are described in Section 7.2.1. Decontamination procedures for Basin F are as follows: personnel will scrub and remove their outer booties and gloves and wash any equipment at the gate. Personnel will then proceed to the wash pad and complete decontamination. SCBA's will remain on until personnel are at the wash pad.

Shooting of animals will be a method of collection for tissue analysis. Before any shooting takes place, field personnel will notify and coordinate with RMA security, the RMA fire department, and all contractors and subcontractors working onpost. It is important that no other field crews are in areas where shooting will be occurring.

7.2.4 CHOLINESTERASE INHIBITION

Cholinesterase inhibition studies will require the collection of animals from the Basin F area. Procedures described in Section 7.2.3 will apply to this activity.

7.2.5 FOOD CHAIN DEFINITION

Food chain definition activities will take place in Section 36 and the Lower Lakes area. Personal protection will be as described in Section 7.2.1. Procedures for shooting are described in Section 7.2.3.

7.2.6 INVERTEBRATE POPULATION STUDIES

Invertebrate population studies will take place in Section 36 and the Lower Lakes area. Procedures are described in Section 7.2.1.

7.2.7 DOMESTICATED PLANTS AND ANIMALS

No field work is anticipated.

7.2.8 PHYSICAL MALFORMATIONS

The investigation for physical malformations will be included with Avian Reproductive Success Investigations described in Section 7.2.2.

7.2.9 HABITAT EVALUATION PROCEDURES

No field work is anticipated.

7.2.10 GENERAL MONITORING AND FIELD COORDINATION

General monitoring and field coordination will take place in the Lower Lakes region. Personal protection and decontamination procedures for this region are described in Section 7.2.1.

7.3 NIGHT WORK AND INCLEMENT WEATHER

Night work may be required for Task 9 activities. If night work is required, field personnel will notify security and the RMA fire department of their specific location. All night work will be accomplished employing the buddy system.

Weather conditions can change rapidly in the RMA area. Strong electrical storms can come in over the mountains with little warning. All field work will immediately cease when lightning is observed. Field personnel will immediately seek cover and remain under cover until the storm or lightning has subsided.

7.4 WOUNDS CAUSED BY ANIMALS

Besides carrying contaminating chemicals in their bodies, animals collected at RMA may also be infested with disease-carrying ticks, fleas, and other parasites. The animals themselves may also be inflicted with or carriers of diseases which could be passed on to humans. Therefore, field personnel handling live or dead animals will at all times wear gloves.

Personnel will check themselves frequently for the presence of fleas and ticks. At lunch and at the end of each day in the field personnel will wash themselves thoroughly after handling animals.

If field personnel are wounded by an animal, whether it be a bite or scratch, the personnel will thoroughly wash the wound and seek immediate medical attention. If it is possible that the animal has rabies, the field personnel should attempt to capture the animal for observation for rabies.

7.5 UNEXPLODED ORDNANCE AND SURETY MATERIAL

It is very unlikely that field personnel will discover surface UXO or munition fragments. If field personnel do find these objects, they will immediately call the command post and give the trailer monitor a description of the object and its location. The trailer monitor will notify the fire department personnel who will then take over identification and recovery procedures.

It is not expected that field personnel will encounter surety materials. However, if there is an incident involving surety materials, procedures outlined in Section 7.0 of the Task 1 Technical Plan will be followed.

8.0 REFERENCES

Adrian, W. 1986. Personal Communication. Colorado Division of Wildlife, Denver, Colorado.

Baxter, G.T. and Simon, J.R. 1970. Wyoming Fishes. Wyoming Game and Fish Department Bulletin No. 4. Cheyenne, Wyoming.

Bellrose, F.C. 1980. Ducks, Geese, and Swans of North America. Stackpole Books, Harrisburg, Pennsylvania.

Berry, E.W. April, 1984. Chemical Monitoring of Fish and Game Animals on Rocky Mountain Arsenal. RIC#85115R01.

Cogley, D.R., Craker, L.E., Torgeson, C.D., and Sirois, D.L. 1979. Biological Testing of Rocky Mountain Arsenal for Phytotoxic Substances. Final Report. Wilmington, Massachusetts. RIC#81266R08.

Cohen, J.E. 1978. Food Webs and Niche Space. Princeton University Press.

Colorado Division of Wildlife (CDOW). 1981. Colorado Reptile and Amphibian Distribution Latilong Study. Second Edition, Non-game Section, Colorado Divison of Wildlife, Denver, Colorado.

Colorado Division of Wildlife (CDOW). 1982a. Colorado Bird Distribution Latilong Study. Colorado Division of Wildlife, Denver, Colorado.

Colorado Division of Wildlife. 1982b. Colorado Mammal Distribution Latilong Study. Colorado Division of Wildlife, Denver, Colorado.

D.P. Associates. 1986. Rocky Mountain Arsenal Ecological Chemical Data (198401985). RIC#86091R02.

Elton, C. 1927. Animal Ecology. MacMillan Company, New York, New York.

Environmental Science and Engineering, Inc. (ESE). 1985. Section 36 Contamination Survey Technical Plan, TAsk 1, Revision A. Volumes I and II. RIC#85127R07.

Fairbanks, R.L. and Kolmer, J.R. 1976. Installation Restoration at Rocky Mountain Arsenal. Environmental Impact Assessment. DOA. RIC#84219R01.

Federal Aviation Administration. 1986. Expansion of Stapleton International Airport, Final EIS. U.S. Department of Transportation. RIC#86293R03.

Finley, R.B., Jr. 1959. Investigations of Waterfowl Mortality at the Rocky Mountain Arsenal. Internal U.S. Fish and Wildlife Service Report, Denver Wildlife Research Center.

Geraghty and Miller, Inc. September 1982. Assessment of Contamination Migration from Potential Contamination Sources. USATHAMA. RIC#81342R06.

Geraghty & Miller, Inc. 1986. Rocky Mountain Arsenal Chemical Index. Volumes I and II. RIC#86107R01.

Gilberton, M. and Fox, G.A. 1977. Pollutant Associated Embryonic Mortality of Great Lakes Herring Gulls. Environ. Poll. 12:211-216.

Hammerson, G. A. 1982. Amphibians and Reptiles in Colorado. Colorado Division of Wildlife Publication No. DOW-M-I-27-82.

Hanson, W.R. and Graybill, F. 1956. Sample Size in Food Habits Analysis. Journal of Wildlife Management 20(1):64-68.

Jensen, W.I. 1955. Waterfowl Mortality, Rocky Mountain Arsenal, Summary Report. U.S. Fish and Wildlife Service Internal Report. Denver, Colorado. RIC#84292R04.

Kolmer, J.R. and Anderson, G.A. 1977. Installation Restoration of Rocky Mountain Arsenal, Part I-Pilot Containment Operations. Final Environmental Impact Statement. DOA. RIC#81295R07.

Lovell, D.C. and Choate, J.R. 1982. Checklist of Mammals, Barr Lake State Park. Museum of the High Plains, Hays, Kansas.

Lyman, M.T. Reehl, W.F., and Rosenblatt, D.H. 1982. Handbook of Chemical Property Estimation Methods. McGraw Hill Book Company, New York.

Martin, A.C., Zim, H.S. and Nelson, A.L. 1951. American Wildlife and Plants: A Guide to Wildlife Food Habits. Dover Publications, Inc., New York, New York.

McEwen, L.C. and DeWeese, L.R. 1984. U.S. Fish and Wildlife Service Investigations of Chemical Contaminants in Animals and Habitats of the Rocky Mountain Arsenal, Denver, Colorado. Special USFWS Report, Patuxent Wildlife Research Center, Rocky Mountain Field Station, Fort Collins, Colorado.

McEwen, L.C. and DeWeese, L.R. 1985. Preliminary Investigations of Aldrin, Dieldrin, Endrin, and Mercury Residues in Eggs and Young of Waterfowl Nesting at the Rocky Mountain Arsenal. Special USFWS Report, Patuxent Wildlife Research Center, Rocky Mountain Field Station, Fort Collins, Colorado.

Program Manager for Chemical Demilitarization Installation Restoration (PMCDIR). March, 1977. Installation Assessment of Rocky Mountain Arsenal Records Evaluation Report #107, Volume I, II, and Appendices. Edgewood, Maryland. RIC#81266R68.

Rosenlund, B., Jennings, D., Kurey, W., Jackson, T. and Bergeson, E. 1986. Contaminants in Aquatic Systems at the Rocky Mountain Arsenal, 1984. U.S. Fish and Wildlife Service, Denver, Colorado. RIC#86041R02.

Sokal, R.R. and Rohlf, F.J. 1981. Biometry. W.H. Freeman and Co., San Francisco, California.

Thompson, D. 1986. Personal Communication. Colorado State University.

Thorne, D.S. 1986a. Rocky Mountain Arsenal Ecology Field Observations (1980-1986). D.P. Associates, Commerce City, Colorado. RIC#86066R01

Thorne, D.S. 1986b. Rocky Mountain Arsenal Ecological Chemical Data (1984-1985). D.P. Associates, Commerce City, Colorado. RIC#86091R02

Torgeson, D.C. and Sirois, D.L. 1976. Report 1 Survey of the Rocky Mountain Arsenal for Phytoxic Substances. Final Comprehensive Report. Boyce Thompson Institute. RIC#81341R02.

U.S. Army Dugway Proving Ground. 1973. Incident Report on the Wildlife Mortalities at Rocky Mountain Arsenal During the Period April 4 through June 14, 1973. Dugway, Utah. RIC#84131R02

U.S. Army Dugway Proving Ground. 1974. Preliminary Environmental Survey of Rocky Mountain Arsenal. Dugway, Utah. RIC#86107R01.

U.S. Army Dugway Proving Ground. 1975a. Interim Report on Pesticide Levels in Fish from Two Industrial lakes at Rocky Mountain Arsenal. Dugway, Utah. RIC#84296R02.

U.S. Army Dugway Proving Ground. 1975b. Interim Report on Pesticide Levels in Fish Collected March 20, 1975 from Lake Ladora at Rocky Mountain Arsenal. Dugway, Utah. RIC#84296R03.

U.S. Army Environmental Hygiene Agency. 1973. Small Animal Deaths-Rocky Mountain Arsenal. Special Study No. 99-055-73/74. U.S. Department of Army, Aberdeen Proving Ground, Maryland.

U.S. Army Environmental Hygiene Agency. 1976. Rocky Mountain Arsenal Bird Kill. Entomological Special Study No. 44-123-76. Aberdeen Proving Ground, Maryland. RIC#83020R03.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1983. Selection of Contamination Control Strategy for Rocky Mountain Arsenal. Vol. I and II. U.S. Army, Aberdeen Proving Ground, Maryland. RIC#83326R01.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1984. Decontamination Assessment of Land and Facilities at Rocky Mountain Arsenal. U.S. Army, Aberdeen Proving Ground, Maryland. RIC#84034R01.

U.S. Department of Interior. 1986. Type B Technical Information Document: Injury to Fish and Wildlife Species. U.S. Department of Interior; Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1983. Methds for Chemical Analysis of Water and Wastes.

U.S. Fish and Wildlife Service. 1961. Special Pesticide Problems. Denver Wildlife Research Center. Unpublished Report.

U.S. Fish and Wildlife Service. 1965. Movement and Accumulation of Aldrin in Lakes at Rocky Mountain Arsenal, Colorado in Relation to Waterfowl Losses. Denver Wildlife Research Center, Denver, Colorado. RIC#84296R04.

U.S. Fish and Wildlife Service. 1982. Chemical Contaminant Residues and Effects of Kestrals and Other Wildlife of the Colorado Rocky Mountain Arsenal. Progress Report. Part 1.

Walter, P.B. and Snider, R.M. 1984. Techniques for Sampling Earthworms and Cocoons from Leaf Litter, Humus, and Soil. Pedobiologia 27:293-297.

MF# RDA 002 1865. 1973. Incident Report on the Wildlife Mortalities at Rocky Mountain Arsenal During the Period April 4, 1973 to June 14, 1973.

MF# RFA 001 0338. 1975. Special Project Report. Fishery Management Program, Rocky Mountain Arsenal.

MF# RFA 002 0061-0068. L.R. DeWeese et al. 1982. Chemical Contaminant Residues and Effects on Kestrels and Other Wildlife of the Colorado Rocky Mountain Arsenal. Progress Report, Part I.

MF# RFA 002 0262F. February 5, 1976. J.G. Linki and H.E. Stiles. Residue Levels Cause Death to Birds, Rocky Mountain Arsenal.

MF# RFA 003 0033. 1961. R.B. Finley, Jr. 40th Annual Conference W. Associate State Game and Fish Commission, pp. 121-129.

MF# RFA 003 0039. February 12, 1985. Effects of Pesticides on Fish and Wildlife: 1964 Research Findings of the U.S. Fish and Wildlife Service. USFWS Circular #226, August 1985.

MF# RFA 003 0107F. McEwen, L. 1982. U.S. Fish and Wildlife Service Investigations of Chemical Contaminants in Animals and Habitats of the Rocky Mountain Arsenal, Denver, Colorado.

MF# RFA 003 0290. DeWeese, L.R., et al. 1982. Chemical Contaminant Residues and Effects on Kestrels and Other Wildlife of the Colorado Rocky Mountain Arsenal. U.S. Fish and Wildlife Service. Progress Report.

MF# RFA 003 0293-0300. 1982. Chemical Contaminant Residues and Effects on Kestrels and Other Wildlife of the Colorado Rocky Mountain Arsenal, Part II.

MF# RFA 003 0301. Organochlorine Chemical Residues in Brains of Birds and One Mammal Found Dead at Rocky Mountain Arsenal in 1982. U.S. Fish and Wildlife Service. 1983.

MF# RFA 003 0659-0661. March 2, 1962. Summary of Wildlife Residues and Toxicities. Pesticide-Wildlife Studies, Denver Wildlife Research Center.

MF# RFA 003 0704. Pesticide Residues at Rocky Mountain Arsenal.

MF# RFA 003 1262F. J. Peterson and R. Finley. Summary Lab Reports on Contaminants in Water, Plant, Wildlife Samples Between April 10, 1959 and December 1, 1961 from Upper and Lower Derby Lake, Rocky Mountain Arsenal.

MF# RFA 003 1673. McEwen L. 1985. Work Papers on Kestrel Studies Submitted to Mr. Thomas Bick, Department of Justice, Washington D.C.

MF# RMA 031 0751F. 1982. Chemical Analysis of Fish and Game Animals.

MF# RMA 036 1495F. Rocky Mountain Arsenal Wildlife Contamination, Notes from U.S. Fish and Wildlife Service, 1952-1982.

MF# RMA 036 1574. 1977. Request for and Results of Tests (Whole Trout).

MF# RMA 036 1575. 1977. Lake Mary Trout Memo: Army.

MF# RMA 037 0170-0185. 1980-1982. Vegetation Contamination Notes.

MF# RMA 045 1751F. Chemical Analysis of Small Animals.

MF# RMA 045 1769F. December 15, 1981. Letter from McNeil to USFWS on Chemical Analysis Report: Fish Samples, June, 1981.

MF# RMA 045 1786. Chemical Monitoring of Fish at Rocky Mountain Arsenal.

MF# RMA 045 1797. May 9, 1980. Memo for Record (Thorne): Chemical Monitoring of Fish and Game Animals on Rocky Mountain Arsenal.

MF# RMA 046 0975. February 1975. Interim Summary Report of Dugway's Findings on the Cause of Waterfowl Mortalities in and Around Reservoir F at Rocky Mountain Arsenal. U.S. Army, Dugway Proving Ground, Utah.

MF# RMA 046 2040. 1980. Contaminants in Wildlife Collected at Rocky Mountain Arsenal.

MF# RMA 076 0736. 1982. Wildlife Contamination at Rocky Mountain Arsenal.

MF# RMA 117 1364-1374. April 23, 1984. Chemical Monitoring of Fish and Game Animals on Rocky Mountain Arsenal.

MF# RMA 134 0649-0652. 1982. Chemical Contaminant Residues and Effects on Kestrels and Other Wildife of Rocky Mountain Arsenal, Part I.

MF# RMA 162 0821F. Summary of Contaminant Levels in Vegetation Near OffPost Wells.

MF# RMA 153 2150-2152. 1984. Congressional Inquiry Regarding Animal Deaths at Rocky Mountain Arsenal Over the Last Ten Years.

MF# RSH 855 1544F. Letters from Fish and Wildlife Service.

MF# RZA 001 2217. 1959. R.B. Finley. Investigations of Waterfowl Mortality at Rocky Mountain Arsenal.

APPENDIX A

PLANT AND ANIMAL SPECIES WHICH INHABIT OR POTENTIALLY OCCUR ON ROCKY MOUNTAIN ARSENAL

Family	Genus	Species	Common Name	Status*	Source Document**
PLANTS					
Verbenaceae	Abronia	fragrans	Prairie snowball		5
Aceraceae	Acer	negundo	Boxelder		5
Aceraceae	Acer	saccharinum	Silver-leaf maple		5
Gramineae	Agropyron	cristatum	Crested wheatgrass		5
Gramineae	Agropyron	desertorum	Crested wheatgrass		5
Gramineae	Agropyron	elongatum	Tall wheatgrass		5
Gramineae	Agropyron	intermedium	Wheatgrass, intermed.		5
Gramineae	Agropyron	repens	Quack grass		5
Gramineae	Agropyron	smithii	Western wheatgrass		5
Gramineae	Agropyron	trachycaulum	Slender wheatgrass		5
Amaranthaceae	Amaranthus	albus	Tumble pigweed		5
Amaranthaceae	Amaranthus	arenicola	Rope-spike pigweed		5
Amaranthaceae	Amaranthus	retroflexus	Rough pigweed		5
Compositae	Ambrosia	psilostachya	Western ragweed		5
Compositae	Antennaria	rosea	Pussy-toes		5
Apocynaceae	Apocynum	sibiricum	Siberian dogbane		5
Papaveraceae	Argemone	polyanthemos	Prickly poppy		5
Gramineae	Aristida	longiseta	Red three-awn		5
Compositae	Artemisia	filifolia	Sand sagebrush		5
Compositae	Artemisia	frigida	Fringed sagebrush		5
Compositae	Artemisia	ludoviciana	Prairie sage		5
Asclepiadaceae	Asclepias	incarnata	Marsh milkweed		5
Asclepiadaceae	Asclepias	speciosa	Showy milkweed		5
Asparagaceae	Asparagus	officinalis	Asparagus		5
Compositae	Aster	commutatus	White prairie aster		5
Leguminosae	Astragalus	lotiflorus	Lotus milk-vetch		5
Chenopodiaceae	Bassia	hyssopifolia	Bassia		5
Umbelliferae	Berula	erecta	Water parsnip		5
Gramineae	Bouteloua	curtipendula	Side-oats grama		5
Gramineae	Bouteloua	gracilis	Blue grama		5
Gramineae	Bromus	inermis	Smooth brome		5
Gramineae	Bromus	japonicus	Japanese brome		5
Gramineae	Bromus	tectorum	Cheatgrass		5
Gramineae	Buchloe	dactyloides	Buffalo grass		5
Gramineae	Calamovilfa	longifolia	Prairie sand reed		5
Cruciferae	Cardaria	draba	Hoary cress		5
Compositae	Carduus	nutans	Musk thistle		5
Cyperaceae	Carex	spp.	Sedge		5
Leguminosae	Catalpa	speciosa	Catalpa		5
Ulmaceae	Celtis	reticulata	Hackberry		5
Chenopodiaceae	Ceratoides	lanata	Winterfat		5
Euphorbiaceae	Chamaesyce	glyptosperma	Corrugate-seed spurge		5
Euphorbiaceae	Chamaesyce	missurica	Narrow-leave spurge		5
Euphorbiaceae	Chamaesyce	serpyllifolia	Thyme-leaved spurge		5
Chenopodiaceae	Chenopodium	album	Pigweed		5
Chenopodiaceae	Chenopodium	leptophylum	Narrow-leaf gooseft		5

Family	Genus	Species	Common Name	Status*	Source Document**
Compositae	Chrysothamnus	nauseosus	Rabbitbrush		5
Compositae	Cirsium	arvense	Canadian thistle		5
Capparidaceae	Cleome	serrulata	Beeweed		5
Convolvulaceae	Convolvulus	arvensis	Morning glory		5
Compositae	Conyza	canadensis	Horseweed		5
Cactaceae	Coryphantha	vivipara	Ball cactus		5
Euphorbiaceae	Croton	texensis	Croton		5
Boraginaceae	Cryptantha	fendleri	Fendler's cryptantha		5
Cucurbitaceae	Cucurbita	foetidissima	Wild gourd		5
Umbelliferae	Cymopterus	montanus	Biscuit root		5
Leguminosae	Dalea	aurea	Prairie clover		5
Cruciferae	Descurainia	sophia	Tansy mustard		5
Gramineae	Distichlis	stricta	Alkali saltgrass		5
Compositae	Dyssodia	papposa	Fetid marigold		5
Cactaceae	Echinocereus	viridiflorus	Hen and chickens		5
Eleagnaceae	Eleagnus	angustifolia	Russian olive		5
Gramineae	Elymus	canadensis	Canadian wild rye		5
Onagraceae	Epilobium	adenocaulon	Willow-herb		5
Gramineae	Eragrostis	cilianensis	Stinkgrass		5
Polygonaceae	Eriogonum	annuum	Tall eriogonum		5
Compositae	Erigeron	divergens	Spreading fleabane		5
Polygonaceae	Eriogonum	effusum	Bushy eriogonum		5
Compositae	Erigeron	pumilus	Low daisy		5
Geraniaceae	Erodium	cicutarium	Filaree		5
Cruciferae	Erysimum	asperum	Western wallflower		5
Euphorbiaceae	Euphorbia	marginata	Snow-on-the-mountain		5
Compositae	Euthamia	graminifolia	Bushy goldenrod		5
Convolvulaceae	Evolvulus	nuttallianus	Bindweed		5
Oleaceae	Fraxinus	pennsylvanica	Green ash		5
Onagraceae	Gaura	coccinea	Scarlet gaura		5
Onagraceae	Gaura	parviflora	Tall gaura		5
Leguminosae	Gleditsia	triacanthos	Honey locust		5
Compositae	Gnaphalium	chilense	Yellow cudweed		5
Compositae	Grindelia	squarrosa	Gumweed		5
Compositae	Gutierrezia	sarothrae	Snakeweed		5
Caryophyllaceae	Gypsophila	paniculata	Baby's breath		5
Compositae	Haplopappus	spinulosus	Spiny goldenweed		5
Compositae	Helianthus	annuus	Common sunflower		5
Compositae	Helianthus	petiolaris	Prairie sunflower		5
Compositae	Heterotheca	villosa	Hairy golden aster		5
Gramineae	Hordeum	jubatum	Foxtail barley		5
Gramineae	Hordeum	pusillum	Little Barley		5
Polemoniaceae	Ipomopsis	laxiflora	Loose-flowered gilia		5
Convolvulaceae	Ipomoea	leptophylla	Bush morning glory		5
Compositae	Iva	xanthifolia	Tall marsh elder		5
Juncaceae	Juncus	arcticus	Creeping rush		5
Pinaceae	Juniperus	virginiana	Rocky Mt. juniper		5
Chenopodiaceae	Kochia	scoparia	Kochia		5
Compositae	Kuhnia	eupatorioides	False boneset		5

Family	Genus	Species	Common Name	Status*	Source Document**
Compositae	Lactuca	serriola	Prickly lettuce		5
Boraginaceae	Lappula	redowskii	Stickweed		5
Cruciferae	Lepidium	perfoliatum	Peppergrass		5
Polemoniaceae	Leptodactylon	pungens	Prickly gilia		5
Liliaceae	Leucocrinum	montanum	Sand lily		5
Compositae	Liatris	punctata	Blazing star		5
Boraginaceae	Lithospermum	incisum	Narrow-leaf puccoon		5
Leguminosae	Lupinus	argenteus	Lupine		5
Compositae	Lygodesmia	juncea	Rush skeleton weed		5
Compositae	Machaeranthera	linearis	Aster		5
Compositae	Machaeranthera	spp	Aster		5
Leguminosae	Medicago	sativa	Alfalfa		5
Leguminosae	Melilotus	alba	White sweet clover		5
Leguminosae	Melilotus	officinalis	Yellow sweet clover		5
Labiatae	Mentha	arvensis	Field mint		5
Loasaceae	Mentzelia	nuda	Evening star		5
Gramineae	Muhlenbergia	asperifolia	Alkali muhly		5
Gramineae	Muhlenbergia	torreyi	Ring muhly		5
Gramineae	Monroa	squarrosa	False buffalo grass		5
Cruciferae	Nasturtium	officinale	Nasturtium		5
Compositae	Nothocalais	cuspidata	False dandelion		5
Onagraceae	Oenothera	albicaulis	Evening primrose		5
Onagraceae	Oenothera	caespitosa	Stemless primrose		5
Onagraceae	Oenothera	coronopifolia	Cut-leaf primrose		5
Onagraceae	Oenothera	nuttallii	Nuttall's primrose		5
Onagraceae	Oenothera	strigosa	Evening primrose		5
Cactaceae	Opuntia	compressa	Prickly pear		5
Cactaceae	Opuntia	polycantha	Starvation cactus		5
Leguminosae	Oxytropis	lambertii	Colorado loco-weed		5
Nyctaginaceae	Oxybaphus	nyctagineus	Umbrella wort		5
Gramineae	Panicum	capillare	Witch grass		5
Vitaceae	Parthenocissus	inserta	Virginia creeper		5
Scrophulariaceae	Penstemon	albidus	White penstemon		5
Scrophulariaceae	Penstemon	angustifolius	Narrow-lf penstemon		5
Polygonaceae	Persicaria	pennsylvanica	Smartweed		5
Solanaceae	Physalis	virginiana	Ground cherry		5
Pinaceae	Picea	pungens	Colorado blue spruce		5
Pinaceae	Pinus	ponderosa	Ponderosa pine		5
Pinaceae	Pinus	sylvestris	Scotch pine		5
Plantaginaceae	Plantago	purshii	Wooly plantain		5
Gramineae	Poa	agassizensis	Mountain bluegrass		5
Polygonaceae	Polygonum	aviculare	Devil's shoestring		5
Capparidaceae	Polanisia	dodecandra	Clammy weed		5
Gramineae	Polypogon	monspeliensis	Rabbitfoot grass		5
Polygonaceae	Polygonum	ramossissiumum	Bushy knotweed		5
Salicaceae	Populus	alba	White poplar		5
Salicaceae	Populus	sargentii	Plains cottonwood		5
Portulacaceae	Portulaca	oleracea	Common purslane		5
Rosaceae	Prunus	americana	Wild plum		5

Family	Genus	Species	Common Name	Status*	Source Document**
Rosaceae	Prunus	virginiana	Choke cherry		5
Pinaceae	Pseudotsuga	menziesii	Douglas fir		5
Leguminosae	Psoralea	tenuiflora	Slender scurf-pea		5
Gramineae	Puccinellia	nuttalliana	Alkali grass		5
Rosaceae	Pyrus	malus	Apple		5
Saxifragaceae	Ribes	aureum	Golden currant		5
Leguminosae	Robinia	neomexicana	New Mexico locust		5
Leguminosae	Robinia	pseudoacacia	Black locust		5
Cruciferae	Rorippa	sinuata	Yellow-cress		5
Polygonaceae	Rumex	crispus	Curly dock		5
Alismataceae	Sagittaria	spp	Arrowhead		5
Salicaceae	Salix	amygdaloides	Peach-leaved willow		5
Chenopodiaceae	Salsola	collina	Russian thistle		5
Salicaceae	Salix	exigua	Sandbar willow		5
Salicaceae	Salix	interior	Sandbar willow		5
Chenopodiaceae	Salsola	kali	Russian thistle		5
Gramineae	Schedonnardus	paniculatus	Tumble grass		5
Cyperaceae	Scirpus	acutus	Compact bulrush		5
Cyperaceae	Scirpus	americanus	American bulrush		5
Labiatae	Scutellaria	galericulata	Marsh skullcap		5
Compositae	Senecio	spartioides	Butterweed		5
Compositae	Senecio	tridenticulatus	3-toothed butterweed		5
Cruciferae	Sisymbrium	altissimum	Tumble mustard		5
Cruciferae	Sisymbrium	officinale	Hedge mustard		5
Gramineae	Sitanion	longifolium	Squirrel tail		5
Solanaceae	Solanum	rostratum	Buffalo-bur		5
Solanaceae	Solanum	triflorum	Cut-leaf nightshade		5
Compositae	Sonchus	uliginosus	Sow thistle		5
Malvaceae	Sphaeralcea	coccinea	Copper mallow		5
Gramineae	Sporobolus	cryptandrus	Sand dropseed		5
Compositae	Stephanomeria	pauciflora	Wire lettuc		5
Gramineae	Stipa	comata	Needle and thread		5
Caprifoliaceae	Symphoricarpos	occidentalis	Snowberry		5
Tamaricaceae	Tamarix	pentandra	Tamarisk		5
Compositae	Taraxacum	officinale	Dandelion		5
Labiatae	Teucrium	canadense	Germander		5
Compositae	Thelesperma	megapotamicum	Greenthread		5
Cruciferae	Thlaspi	arvense	Penny-cress		5
Tiliaceae	Tilia	spp.	Basswood		5
Compositae	Tragopogon	dubius	Yellow salsify		5
Commelinaceae	Tradescantia	occidentalis	Western spiderwort		5
Zygophyllaceae	Tribulus	terrestris	Puncture vine		5
Typhaceae	Typha	angustifolia	Narrow-leaf cattail		5
Typhaceae	Typha	latifolia	Broad-leaf cattail		5
Ulmaceae	Ulmus	americana	American elm		5
Ulmaceae	Ulmus	parvifolia	Chinese elm		5
Urticaceae	Urtica	dioica	Stinging nettle		5
Scrophulariaceae	Veronica	americana	American Brooklime		5
Scrophulariaceae	Veronica	anagallis	Water Speedwell		5

Family	Genus	Species	Common Name	Status*	Source Document**
Verbenaceae	Verbena	bracteata	Bracted verbena		5
Compositae	Verbesina	encelioides	Crownbeard		5
Scrophulariaceae	Verbascum	thapsus	Great mullein		5
Leguminosae	Vicia	villosa	Vetch		5
Violaceae	Viola	nuttallii	Nuttall's violet		5
Gramineae	Vulpia	octoflora	Six-weeks fescue		5
Liliaceae	Yucca	glauca	Spanish bayonet		5
Gramineae	Zea	mays	Corn		5
Liliaceae	Zygadenus	venenosus	Death camus		5

FISH

Family	Genus	Species	Common Name	Status*	Source Document**
Salmonidae	Salmo	gairdneri	Rainbow Trout	I	1,2
Esocidae	Esox	lucius	Northern Pike	I	1,2
Catostomidae	Catostomus	catostomusi	Longnose Sucker		1,2
Catostomidae	Catostomus	commersoni	White Sucker		1,2
Cyprinidae	Cyprinus	carpio	Carp		1,2
Cyprinidae	Semotilus	atromaculatus	Northern Creek Chub		1
Cyprinidae	Rhinichthys	cattaraceae	Longnose dace		1
Cyprinidae	Notropis	cornutus	Common Shiner		1
Cyprinidae	Notropis	deliciousus	Plains Sand Shiner		1
Cyprinidae	Notropis	dorsalis	Bigmouth Shiner		1
Cyprinidae	Notropis	lutensis	Plains Red Shiner		1,2
Cyprinidae	Hybrognathus	placita	Plains minnow		1
Cyprinidae	Pimephales	promelas	Fathead minnow		1,2
Cyprinidae	Campostoma	anomalum	Plains stoneroller		1
Ameiuridae	Ictalurus	punctatus	Channel catfish	I	1,2
Ameiuridae	Ictalurus	melas	Black Bullhead		1,2
Ameiuridae	Fundulus	kansae	Plains killifish		1,2
Ameiuridae	Fundulus	sciadicus	Plains top minnow		1,2
Centrarchidae	Micropterus	salmoides	Large mouth bass	G,	1,2
Centrarchidae	Lepomis	cyanellus	Green sunfish		1,2
Centrarchidae	Lepomis	gibbosus	Pumpkin seed		1,
Centrarchidae	Lepomis	macrochirus	Northern bluegill		1,2
Centrarchidae	Pomoxis	nigromaculatus	Black crappie		1
Centrarchidae	Lepomis	miggolophys	Red-ear sunfish		1
Percidae	Perca	flavescens	Yellow perch		1,2

AMPHIBIANS

Family	Genus	Species	Common Name	Status*	Source Document**
Pelobatidae	Scaphiopus	bombifrons	Plains spadefoot	B	1,2
Bufonidae	Bufo	w.woodhousei	Woodhouse's toad	B	1,2
Bufonidae	Bufo	cognatus	Great Plains toad	B	1,2
Hylidae	Acris	crepitans	Cricket frog		1
Ranidae	Rana	pipiens	Leopard frog	B	1,2
Ranidae	Rana	catesbeiana	Bullfrog	B	1,2
Ambystomidae	Ambystoma	tigrinum	Tiger salamander	B	1,2

REPTILES

Family	Genus	Species	Common Name	Status*	Source Document**
Chelydridae	Chelydra	s.serpentina	Snapping turtle	b	1,2
Testudinidae	Chrysemys	picta belli	Painted turtle	B	1,2
Testudinidae	Terrapene	o.ornata	Western box turtle	B	1,2
Trionychidae	Trionyx	spiniferus har.	Soft-shelled turtle	b	1,2
Iguanidae	Holbrookia	m.maculata	Earless lizard	B	1,2
Iguanidae	Sceloporus	undulatus eryt.	Fence lizard	B	1,2
Iguanidae	Phyrnosoma	douglassi	Short-horned lizard	B	1,2
Iguanidae	Sceloporus	undulatus garm.	No.prairie lizard	B	2
Scincidae	Eumeces	obsoletus	Great Plains skink		1
Scincidae	Eumeces	m.multivirgatus	Many-lined skink	B	1,2
Teiidae	Cnemidophorus	sexlineatus vi.	Six-lined racerunner	B	1,2
Colubridae	Heterodon	n.nasicus	W. Hognose snake	B	1,2
Colubridae	Coluber	constrictor fl.	Racer	B	1,2
Colubridae	Pituophis	melanoleucus s.	Bullsnake	B	1,2
Colubridae	Lampropeltis	triangulum	Milk snake	B	1,2
Colubridae	Thamnophis	sirtalis parie.	Common garter snake	B	1,2
Colubridae	Thamnophis	radix haydeni	Plains garter snake	B	1,2
Colubridae	Tropidoclonion	l.lineatum	Lined snake	B	1,2
Colubridae	Thamnophis	elegans vagrans	Terrestrial garter	B	2
Colubridae	Masticophis	flagellum test.	Coachwhip	B	2
Colubridae	Nerodia	sipedon sipedon	Northern water snake	B	2
Colubridae	Opheodrys	vernalis blanc.	Smooth green snake	B	2
Viperidae	Crotalus	viridis viridis	Prairie rattlesnake	B	1,2

BIRDS

Family	Genus	Species	Common Name	Status*	Source Document**
Gaviidae	Gavia	immer	Common loon	M	1,2,3
Gaviidae	Gavia	arctica	Arctic loon	M	1,2
Gaviidae	Gavia	stellata	Red-throated loon	M	1,2
Podicipedidae	Podiceps	grisegena	Red-necked grebe	M	1,2
Podicipedidae	Podiceps	auritus	Horned grebe	M	1,2,3
Podicipedidae	Podiceps	nigricollis	Eared grebe	b	1,2,3
Podicipedidae	Aechmophorus	occidentalis	Western grebe	B	1,2,3
Podicipedidae	Podilymbus	podiceps	Pied-billed grebe	R	1,2,3,4
Pelecanidae	Pelecanus	erythrorhynchos	White pelican	n	1,2,3
Phalacrocoracidae	Phalacrocorax	auritus	Dble-cr.cormorant	B	1,2,3
Phalacrocoracidae	Phalacrocorax	olivaceus	Olivaceous cormorant	M	1,2
Anhingidae	Anhinga	anhinga	Anhinga		1
Ardeidae	Ardea	herodias	Great blue heron	R	1,2,3,4
Ardeidae	Butorides	striatus	Green-backed heron	M	1,2,3
Ardeidae	Egretta	caerulea	Little blue heron	M	1,2,
Ardeidae	Bubulcus	ibis	Cattle egret	n	1,2
Ardeidae	Casmerodius	albus	Great egret	n	1,2,3
Ardeidae	Egretta	thula	Snowy egret	B	1,2,3
Ardeidae	Egretta	tricolor	Tri-colored heron	M	1,2
Ardeidae	Nycticorax	nycticorax	Bl.crown night heron	B	1,2,3
Ardeidae	Ncyticorax	violaceus	Yell.cr.night heron	b	1,2,3
Ardeidae	Botaurus	lentiginosus	American bittern	b	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Ciconiidae	Ayctaria	americana	Wood stork		1
Threskiorniithidae	Plegadis	chihi	White-faced ibis	M	1,2,3
Anatidae	Olor	columbianus	Whistling swan		1
Anatidae	Branta	bernicla	Brant	M	1,2
Anatidae	Branta	canadensis	Canada goose	R	1,2,3,4
Anatidae	Anser	albifrons	White-fronted goose	M	1,2
Anatidae	Chen	caerulescens	Snow goose	M	1,2,3
Anatidae	Chen	rossii	Ross's goose	M	1,2
Anatidae	Anas	platyrhynchos	Mallard	R	1,2,3,4
Anatidae	Anas	diazi	Mexican duck		1
Anatidae	Anas	rubripes	Black duck	M	1,2
Anatidae	Anas	fulvigula	Mottled duck		1
Anatidae	Anas	strepera	Gadwall	R	1,2,3,4
Anatidae	Anas	acuta	Pintail	R	1,2,3,4
Anatidae	Anas	crecca	Green-winged teal	R	1,2,3
Anatidae	Anas	discors	Blue-winged teal	B	1,2,3,4
Anatidae	Anas	cyanoptera	Cinnamon teal	B	1,2,3,4
Anatidae	Anas	americana	American wigeon	R	1,2,3,4
Anatidae	Anas	clypeata	Northern shoveler	R	1,2,3,4
Anatidae	Aix	sponsa	Wood duck	R	1,2,3
Anatidae	Aythya	americana	Redhead	R	1,2,3,4
Anatidae	Aythya	collaris	Ring-necked duck	W	1,2,3,4
Anatidae	Aythya	valisineria	Canvasback	N	1,2,3
Anatidae	Aythya	marila	Greater scaup	M	1,2,3
Anatidae	Aythya	affinis	Lesser scaup	W	1,2,3
Anatidae	Bucephala	clangula	Common goldeneye	W	1,2,3
Anatidae	Bucephala	islandica	Barrows goldeneye	W	1,2
Anatidae	Bucephala	albeola	Bufflehead	W	1,2,3
Anatidae	Clangula	hyemalis	Oldsquaw	M	1,2,3
Anatidae	Somateria	mollissima	Common eider		1
Anatidae	Melanitta	fusca	White-winged scoter	M	1,2
Anatidae	Melanitta	perspicillata	Surf scoter	M	1,2
Anatidae	Melanitta	nigra	Black scoter	M	1,2
Anatidae	Oxyura	jamaicensis	Ruddy duck	B	1,2,3
Anatidae	Lophodytes	cucullatus	Hooded merganser	W	1,2,3
Anatidae	Mergus	merganser	Common merganser	W	1,2,3
Anatidae	Mergus	serrator	Red-breast merganser	M	1,2,3
Cathartidae	Cathartes	aura	Turkey vulture	B	1,2,3
Accipitridae	Accipiter	gentilis	Goshawk	B	1,2
Accipitridae	Accipiter	striatus	Sharp-shinned hawk	B	1,2,3
Accipitridae	Accipiter	cooperii	Cooper's hawk	B	1,2,3
Accipitridae	Buteo	jamaicensis	Red-tailed hawk	R	1,2,3,4
Accipitridae	Buteo	lineatus	Red-shouldered hawk	M	1,2
Accipitridae	Buteo	platypterus	Broad-winged hawk	M	1,2
Accipitridae	Buteo	swainsoni	Swainson's hawk	B	1,2,3,4
Accipitridae	Buteo	lagopus	Rough-legged hawk	W	1,2,3,4
Accipitridae	Buteo	regalis	Ferruginous hawk	R	1,2,3,4
Accipitridae	Aquila	chrysaetos	Golden eagle	R	1,2,3
Accipitridae	Haliaeetus	leucocephalus	Bald eagle	W	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Accipitridae	Circus	cyaneus	Northern Harrier	R	1,2,3,4
Pandionidae	Pandion	haliaetus	Osprey	M	1,2
Falconidae	Falco	rusticolus	Gyrfalcon	M	1,2
Falconidae	Falco	mexicanus	Prairie falcon	R	1,2,3
Falconidae	Falco	peregrinus	Peregrine falcon	M	1,2,3
Falconidae	Falco	columbarius	Merlin	W	1,2,3
Falconidae	Falco	sparverius	American kestrel	R	1,2,3
Tetraonidae	Tympanuchus	phasianellus	Sharp-tailed grouse	R,E	1,2
Phasianidae	Phasianus	colchicus	Ring-necked pheasant	R	1,2,3,4
Phasianidae	Alectoris	chukar	Chukar	N	1,2
Phasianidae	Colinus	virginianus	Bobwhite	R	1,2
Phasianidae	Callipepla	squamata	Scaled quail	b	2
Gruidae	Grus	canadensis	Sandhill crane	M	1,2,3
Meleagrididae	Meleagris	gallopavo	Wild turkey	R	1,2
Rallidae	Rallus	limicola	Virginia rail	R	1,2,3
Rallidae	Porzana	carolina	Sora	B	1,2,3
Rallidae	Coturnicops	noveboracensis	Yellow rail		1
Rallidae	Laterallus	jamaicensis	Black rail		1
Rallidae	Gallinula	chloropus	Common gallinule		1
Rallidae	Fulica	americana	American coot	R	1,2,3,4
Charadriidae	Charadrius	semipalmatus	Semipalmated plover	M	1,2,3
Charadriidae	Charadrius	melodus	Piping plover	M	1,2,
Charadriidae	Charadrius	alexandrinus	Snowy plover	M	1,2
Charadriidae	Charadrius	vociferus	Killdeer	R	1,2,3
Charadriidae	Charadrius	montanus	Mountain plover	b	1,2
Charadriidae	Pluvialis	dominica	Amer.golden plover	M	1,2
Charadriidae	Pluvialis	squatarola	Black-bellied plover	M	1,2,3
Scolopacidae	Arenaria	interpres	Ruddy turnstone	M	1,2
Scolopacidae	Philohela	minor	American woodcock		1
Scolopacidae	Gallinago	gallinago	Common snipe	R	1,2,3
Scolopacidae	Numenius	americanus	Long-billed curlew	M	1,2,3
Scolopacidae	Numenius	phaeopus	Whimbrel	M	1,2
Scolopacidae	Bartramia	longicauda	Upland sandpiper	b	1,2
Solopacidae	Actitis	macularia	Spotted sandpiper	B	1,2,3
Scolopacidae	Tringa	solitaria	Solitary sandpiper	M	1,2,3
Scolopacidae	Tringa	melanoleuca	Greater yellowlegs	M	1,2,3,4
Scolopacidae	Tringa	flavipes	Lesser yellowlegs	M	1,2,3,4
Scolopacidae	Catoptrophorus	semipalmatus	Willet	M	1,2,3
Scolopacidae	Calidris	canutus	Red knot	M	1,2
Scolopacidae	Calidris	melanotos	Pectoral sandpiper	M	1,2,3
Scolopacidae	Calidris	fuscicollis	Wh.-rump sandpiper	M	1,2
Scolopacidae	Calidris	bairdii	Baird's sandpiper	M	1,2,3
Scolopacidae	Calidris	minutilla	Least sandpiper	M	1,2,3
Scolopacidae	Calidris	alpina	Dunlin	M	1,2
Scolopacidae	Calidris	pusilla	Semipalm.sandpiper	M	1,2,3
Scolopacidae	Calidris	mauri	Western sandpiper	M	1,2,3
Scolopacidae	Calidris	alba	Sanderling	M	1,2,3
Scolopacidae	Limnodromus	griseus	Short-bill dowitcher	M	1,2
Scolopacidae	Limnodromus	scolopaceus	Long-bill dowitcher	M	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Scolopacidae	Calidris	himantopus	Stilt sandpiper	M	1,2,3
Scolopacidae	Tryngites	subruficollis	Buffbreast sandpiper	M	1,2
Scolopacidae	Limosa	haemastica	Hudsonian godwit	M	2
Scolopacidae	Limosa	fedoa	Marbled godwit	M	2
Recurvirostridae	Recurvirostra	americana	American avocet	B	1,2,3,4
Recurvirostridae	Himantopus	mexicanus	Black-necked stilt	M	1,2,3
Phalaropodidae	Phalaropus	fulicaria	Red phalarope	M	1,2,
Phalaropodidae	Phalaropus	lobatus	Northern phalarope	M	1,2
Phalaropodidae	Phalaropus	tricolor	Wilson's phalarope	B	1,2,3
Stercorariidae	Stercorarius	pomarinus	Pomarine jaeger	M	1,2
Stercorariidae	Stercorarius	parasiticus	Parasitic jaeger	M	1,2
Laridae	Larus	minutus	Little gull	M	2
Laridae	Larus	marinus	Gr.black-backed gull	W	2
Laridae	Larus	hyperboreus	Glaucous gull	W	1,2
Laridae	Larus	glaucoides	Iceland gull		1
Laridae	Larus	argentatus	Herring gull	W	1,2,3
Laridae	Larus	thayeri	Thayer's gull	W	1,2
Laridae	Larus	californicus	California gull	N	1,2,3
Laridae	Larus	delawarensis	Ring-billed gull	N	1,2,3
Laridae	Larus	atricilla	Laughing gull	M	1,2
Laridae	Larus	pipixcan	Franklin's gull	M	1,2,3
Laridae	Larus	philadelphia	Bonaparte's gull	M	1,2,3
Laridae.	Pagophila	eburnea	Ivory gull		1
Laridae	Rissa	tridactyla	Bl.legged kittiwake	M	1,2
Laridae	Xema	sabini	Sabine's gull	M	1,2
Laridae	Larus	forsteri	Forster's tern	B	1,2,3
Laridae	Sterna	hirundo	Common tern	M	1,2
Laridae	Sterna	paradisaea	Arctic tern		1
Laridae	Sterna	albifrons	Least tern		1
Laridae	Chlidonias	niger	Black tern	B	1,2,3
Alcidae	Synthliboramphus	antiquus	Ancient murrelet		1
Columbidae	Columba	livia	Rock dove	R	2,3
Colmbidae	Zenaida	macroura	Mourning dove	R	1,2,3
Columbidae	Columba	fasciata	Band-tailed pigeon	B	2
Cuculidae	Coccyzus	americanus	Yellow-bill cuckoo	b	1,2
Cuculidae	Coccyzus	erythropthalmus	Black-billed cuckoo	b	1,2
Tytonidae	Tyto	alba	Barn owl	R	1,2
Strigidae	Otus	kennicottii	Western screech owl	R	2
Strigidae	Otus	asio	Screech owl	R	1,2,3
Strigidae	Bubo	virginianus	Great horned owl	R	1,2,3
Strigidae	Nyctea	scandiaca	Snowy owl	W	1,2
Strigidae	Glaucidium	gnoma	Pygmy owl	W	1,2
Strigidae	Athene	cunicularia	Burrowing owl	B	1,2,4
Strigidae	Strix	occidentalis	Spotted owl	M	1,2
Strigidae	Asia	otus	Long-eared owl	R	1,2,3
Strigidae	Asia	flammeus	Short-eared owl	R	1,2
Strigidae	Aegolius	acadicus	Saw-whet owl	R	1,2
Caprimulgidae	Phalaenoptilus	nuttalii	Common poorwill	B	1,2,3
Caprimulgidae	Chordeiles	minor	Common nighthawk	B	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Apodidae	Chaetura	pelagica	Chimney swift	B	1,2
Trochilidae	Archilochus	alexandri	Bl.-chin hummingbird		1
Trochilidae	Selasphorus	platycercus	Br.-tail hummingbird	B	1,2,3
Trochilidae	Selasphorus	rufus	Rufous hummingbird	M	1,2
Trochilidae	Stellula	calliope	Calliope hummingbird	B	2
Alcedinidae	Ceryle	alcyon	Belted kingfisher	R	2
Picidae	Colaptes	auratus	Common flicker	R	1,2
Picidae	Melanerpes	carolinus	Red-belly woodpecker	M	1,2
Picidae	Melanerpes	erythrocephalus	Red-head woodpecker	B	1,2,3
Picidae	Melanerpes	lewis	Lewis's woodpecker	R	1,2
Picidae	Sphyrapicus	varius	Yel.-belly sapsucker	N	1,2
Picidae	Picoides	villosus	Hairy woodpecker	R	1,2,3
Picidae	Picoides	pubescens	Downy woodpecker	R	1,2,3
Tyrannidae	Tyrannus	tyrannus	Eastern kingbird	B	1,2,3
Tyrannidae	Tyrannus	verticalis	Western kingbird	B	1,2,3
Tyrannidae	Tyrannus	vociferans	Cassin's kingbird	b	1,2,3
Tyrannidae	Tyrannus	forficatus	Scis.tail flycatcher	M	1,2
Tyrannidae	Myiarchus	crinitus	Gr-crest flycatcher	M	1,2
Tyrannidae	Myiarchus	cinerascens	Ashthroat flycatcher	M	1,2
Tyrannidae	Sayornis	phoebe	Eastern phoebe	M	1,2
Tyrannidae	Sayornis	saya	Say's phoebe	B	1,2,3
Tyrannidae	Empidonax	traillii	Willow flycatcher	M	1,2,3
Tyrannidae	Empidonax	alnorum	Alder flycatcher		1
Tyrannidae	Empidonax	minimus	Least flycatcher	M	1,2
Tyrannidae	Empidonax	hammondii	Hammond's flycatcher	M	1,2,3
Tyrannidae	Empidonax	oberholseri	Dusky flycatcher	M	1,2,3
Tyrannidae	Empidonax	difficilis	Western flycatcher	M	1,2,3
Tyrannidae	Contopus	virens	Eastern wood pewee		1
Tyrannidae	Contopus	sordidulus	Western wood pewee	B	1,2,3
Tyrannidae	Contopus	borealis	Oliv-sid.flycatcher	M	1,2,3
Tyrannidae	Pyrocephalus	rubinus	Vermill. flycatcher	M	1,2
Alaudidae	Eremophila	alpestris	Horned lark	R	1,2,3
Hirundinidae	Tachycineta	thalassina	Violet-green swallow	M	1,2,3
Hirundinidae	Tachycineta	bicolor	Tree swallow	B	1,2,3
Hiirundinidae	Riparia	riparia	Bank swallow	B	1,2,3
Hirundinidae	Stelgidopteryx	serripennis	Rough-winged swallow	B	1,2,3
Hirundinidae	Hirundo	rustica	Barn swallow	B	1,2,3
Hirundinidae	Hirundo	pyrrhonota	Cliff swallow	B	1,2,3
Corvidae	Cyanocitta	cristata	Blue jay	R	1,2,3
Corvidae	Nucifraga	columbiana	Clark's nutcracker	M	1,2
Corvidae	Corvus	corax	Common raven	W	2
Corvidae	Pica	pica	Black-billed magpie	R	1,2
Corvidae	Corvus	cryptoleucus	Chihuahuan raven	M	1,2
Corvidae	Corvus	brachyrhynchos	Common crow	R	1,2,3
Corvidae	Gymnorthinus	Cyanocephalus	Pinyon jay	M	1,2
Paridae	Parus	atricapillus	Black-cap chickadee	R	1,2,3
Paridae	Parus	gambeli	Mountain chickadee	W	1,2,3
Paridae	Psaltriparus	minimus	Bushtit		1
Sittidae	Sitta	carolinensis	Wh.breasted nuthatch	R	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Sittidae	Sitta	canadensis	Rd-breasted nuthatch	R	1,2,3
Sittidae	Certhia	americana	Brown creeper	R	1,2
Troglodytidae	Troglodytes	aedon	House wren	B	1,2,3
Troglodytes	Troglodytes	troglodytes	Winter wren	W	1,2
Troglodytidae	Thryomanes	bewickii	Bewick's wren	W	1,2
Troglodytidae	Thryothorus	ludovicianus	Carolina wren	M	1,2
Troglodytidae	Telmatodytes	palustris	Long-bill marsh wren		1
Troglodytidae	Salpinctes	obsoletus	Rock wren	b	1,2,3
Troglodytidae	Cistothorus	palustris	Marsh wren	R	2
Mimidae	Mimus	polyglottos	Mockingbird	R	1,2,3
Mimidae	Dumetella	carolinensis	Gray catbird	B	1,2,3
Mimidae	Toxostoma	curvirostre	Curved-bill thrasher		1
Mimidae	Toxostoma	rufum	Brown thrasher	B	1,2,3
Mimidae	Oreoscoptes	montanus	Sage thrasher	B	1,2,3
Turdidae	Turdus	migratorius	American robin	R	1,2
Turdidae	Hylocichla	mustelina	Wood thrush	M	1,2
Turdidae	Catharus	ustulatus	Swainson's thrush	B	1,2,3
Turdidae	Catharus	minimus	Gray-cheeked thrush	M	1,2
Turdidae	Catharus	fuscescens	Veery	B	1,2,3
Turdidae	Sialia	sialis	Eastern bluebird	M	1,2
Turdidae	Sialia	mexicana	Western bluebird	B	1,2,3
Turdidae	Myadestes	townsendii	Townsend's solitaire	W	1,2,3
Turdidae	Sialia	currucoides	Mountain bluebird	B	1,2,3
Cinclidae	Cinclus	mexicanus	Dipper	W	1,2
Sylviidae	Polioptila	caerulea	Bluegray gnatcatcher	M	1,2,3
Sylviidae	Regulus	satrapa	Golden-crown kinglet	W	1,2,3
Sylviidae	Regulus	calendula	Ruby-crowned kinglet	M	1,2,3
Motacillidae	Anthus	spinoletta	Water pipit	M	1,2,3
Motacillidae	Anthus	spragueii	Sprague's pipit	M	1,2
Bombycillidae	Bombycilla	garrulus	Bohemian waxwing	W	1,2
Bombycillidae	Bombycilla	cedrorum	Cedar waxwing	W	1,2
Ptilogonatidae	Phainopepla	nitens	Phainopepla		1
Laniidae	Lanius	excubitor	Northern shrike	W	1,2,3
Laniidae	Lanius	ludovicianus	Loggerhead shrike	B	1,2,3
Sturnidae	Sturnus	vulgaris	Starling	R,I	1,2,3
Vireonidae	Vireo	bellii	Bell's vireo		1
Vireonidae	Vireo	flavifrons	Yellowthroated vireo		1
Vireonidae	Vireo	solitarius	Solitary vireo	B	1,2,3
Vireonidae	Vireo	olivaceus	Red-eyed vireo	B	1,2,3
Vireonidae	Vireo	philadelphicus	Philadelphia vireo	M	1,2
Vireonidae	Vireo	gilvus	Warbling vireo	B	1,2,3
Parulidae	Mniotilta	varia	Bl. & white warbler	M	1,2,3
Parulidae	Protonotaria	citrea	Prothonotary warbler	M	1,2
Parulidae	Vermivora	celata	Orange-crown warbler	M	1,2,3
Parulidae	Vermivora	peregrina	Tennessee warbler	M	1,2,3
Parulidae	Vermivora	chrsoptera	Golden-wing warbler	M	1,2
Parulidae	Vermivora	pinus	Blue-winged warbler	M	1,2
Parulidae	Vermivora	ruficapilla	Nashville warbler	M	1,2,3
Parulidae	Vermivora	virginiae	Virginia's warbler	B	1,2,3

Family	Genus	Species	Common Name	Status*	Source Document**
Parulidae	Parula	americana	Northern parula	M	1,2,3,
Parulidae	Dendroica	petchnia	Yellow warbler	B	1,2,3
Parulidae	Dendroica	magnolia	Magnolia warbler	M	1,2
Parulidae	Dendroica	caerulescens	Blackthroat warbler	M	1,2
Paulidae	Dendroica	coronata	Yellowrumped warbler	M	1,2,3
Paulidae	Dendroica	nigrescens	Bl.throat gr.warbler	M	1,2
Parulidae	Dendroica	townsendi	Townsend's warbler	M	1,2,3
Parulidae	Dendroica	virens	Bl.throat green warb	M	1,2,3
Parulidae	Dendroica	cerulea	Cerulean warbler		1
Parulidae	Dendroica	graciae	Grace's warbler		1
Parulidae	Dendroica	fusca	Blackburnian warbler	M	1,2
Parulidae	Dendroica	dominica	Yellowthroat warbler	M	1,2
Parulidae	Dendroica	pensylvanica	Chestnutside warbler	M	1,2,3
Parulidae	Dendroica	castanea	Bay-breasted warbler	B	1,2
Parulidae	Dendroica	striata	Blackpoll warbler	M	1,2,3
Parulidae	Dendroica	pinus	Pine warbler		1
Parulidae	Dendroica	palmarum	Palm warbler	M	1,2
Parulidae	Seiurus	aurocapillus	Ovenbird	B	1,2,3
Parulidae	Seiurus	noveboracensis	Northern waterthrush	M	1,2,3
Parulidae	Oporornis	tolmiei	MacGillivray warbler	M	1,2,3
Parulidae	Geothlypis	trichas	Common yellowthroat	B	1,2,3
Parulidae	Icteria	virens	Yellow-breasted chat	B	1,2,3
Parulidae	Wilsonia	citrina	Hooded warbler	M	1,2
Parulidae	Wilsonia	pusilla	Wilson's warbler	M	1,2,3
Parulidae	Wilsonia	canadensis	Canada warbler	M	1,2
Parulidae	Setophaga	ruticilla	American redstart	B	1,2,3
Parulidae	Helmitheros	vermivorus	Worm-eating warbler	M	1,2
Passeridae	Passer	domesticus	House sparrow	R,I	1,2,3
Icteridae	Dolichonyx	oryzivorus	Bobolink	B	1,2
Icteridae	Sturnella	neglecta	Western meadowlark	R	1,2,3
Icteridae	Xanthocephalus	xanthocephalus	Yellowhead blackbird	B	1,2,3
Icteridae	Agelaius	phoeniceus	Red-winged blackbird	R	1,2,3
Icteridae	Icterus	spurius	Orchard oriole	B	1,2,3
Icteridae	Icterus	galbula	Northern oriole	B	1,2,3
Parulidae	Euphagus	carolinus	Rusty blackbird	W	1,2
Parulidae	Euphagus	cyanocephalus	Brewer's blackbird	R	1,2,3
Icteridae	Quiscalus	quiscula	Common grackle	B	1,2,3
Icteridae	Molothrus	ater	Brown-headed cowbird	B	1,2,3
Thraupidae	Piranga	ludoviciana	Western tanager	B	1,2
Thraupidae	Piranga	olivacea	Scarlet tanager	M	1,2
Thraupidae	Piranga	rubra	Summer tanager	M	1,2
Fringillidae	Cardinalis	cardinalis	Cardinal	N	1,2
Fringillidae	Pheucticus	ludovicianus	Rose-breast grosbeak	M	1,2,3
Fringillidae	Pheucticus	melanocephalus	Blackheaded grosbeak	B	1,2,3
Fringillidae	Guiraca	caerulea	Blue grosbeak	B	1,2,3
Fringillidae	Passerina	cyanea	Indigo bunting	B	1,2,3
Fringillidae	Passerina	amoena	Lazuli bunting	B	1,2,3
Fringillidae	Passerina	ciris	Painted bunting	M	1,2
Fringillidae	Spiza	americana	Dickcissel	B	1,2

Family	Genus	Species	Common Name	Status*	Source Document**
Fringillidae	Coccothraustes	vespertinus	Evening grosbeak	R	1,2
Fringillidae	Carpodacus	purpureus	Purple finch	W	1,2
Fringillidae	Carpodacus	cassinii	Cassin's finch	W	1,2
Fringillidae	Carpodacus	mexicanus	House finch	R	1,2,3
Fringillidae	Pinicola	enucleator	Pine grosbeak	W	1,2
Fringillidae	Leucosticte	arctoa	Rosy finch	W	2
Fringillidae	Leucosticte	atrata	Black rosy finch		1
Fringillidae	Leucosticte	australis	Brown-cap rosy finch		1
Fringillidae	Carduelis	flammea	Common redpoll	W	1,2,3
Fringillidae	Carduelis	pinus	Pine siskin	R	1,2,3
Fringillidae	Carduelis	tristis	American goldfinch	R	1,2,3
Fringillidae	Carduelis	psaltria	Lesser goldfinch	B	1,2
Fringillidae	Loxia	curvirostra	Red crossbill	R	1,2
Fringillidae	Loxia	leucoptera	White-wing crossbill	W	1,2
Fringillidae	Pipilo	chlorurus	Green-tailed towhee	b	1,2,3
Fringillidae	Pipilo	erythrophthalmus	Rufous-sided towhee	B	1,2,3
Fringillidae	Pipilo	fuscus	Brown towhee		1
Fringillidae	Calamospiza	melanocorys	Lark bunting	B	1,2,3
Fringillidae	Passerculus	sandwichensis	Savannah Sparrow	B	1,2,3
Fringillidae	Ammodramus	savannarum	Grasshopper sparrow	B	1,2
Fringillidae	Ammodramus	bairdii	Baird's sparrow	M	1,2
Fringillidae	Ammodramus	leconteii	Le Conte's sparrow		1
Fringillidae	Pooecetes	gramineus	Vesper sparrow	B	1,2,3
Fringillidae	Chondestes	grammacus	Lark sparrow	B	1,2,3
Fringillidae	Aimophila	ruficeps	Rufous-crown sparrow		1
Fringillidae	Aimophila	cassinii	Cassin's sparrow	b	1,2
Fringillidae	Amphispiza	bilineata	Black-throat sparrow	M	1,2
Fringillidae	Amphispiza	belli	Sage sparrow	M	1,2
Fringillidae	Junco	hyemalis	Dark-eyed junco	W	1,2,3
Fringillidae	Spizella	arborea	Tree sparrow	W	1,2,3
Fringillidae	Spizella	passerina	Chipping sparrow	B	1,2,3
Fringillidae	Spizella	pallida	Clay-colored sparrow	M	1,2,3
Fringillidae	Spizella	breweri	Brewer's sparrow	B	1,2,3
Fringillidae	Spizella	pusilla	Field sparrow	M	1,2
Fringillidae	Passerella	iliaca	Fox sparrow	W	1,2
Fringillidae	Melospiza	melodia	Song sparrow	R	1,2,3
Fringillidae	Melospiza	lincolnii	Lincoln's sparrow	M	1,2,3
Fringillidae	Melospiza	georgiana	Swamp sparrow	W	1,2
Fringillidae	Zonotrichia	leucophrys	White-crown sparrow	W	1,2,3
Fringillidae	Zonotrichia	querula	Harris's sparrow	W	1,2,3
Fringillidae	Calcarius	mccownii	McCown's longspur	M	1,2
Fringillidae	Calcarius	lapponicus	Lapland longspur	W	1,2
Fringillidae	Plectrophenax	nivalis	Snow bunting	W	1,2

MAMMALS

Didelphidae	Didelphis	virginiana	Opossum	b	1,2
Soricidae	Sorex	cinereus	Masked shrew	B	2
Soricidae	Sorex	merriami	Merriam's shrew	B	1,2

Family	Genus	Species	Common Name	Status*	Source Document**
Soricidae	Cryptotis	parva	Least shrew	B	1,2,3
Vespertilionidae	Myotis	lucifugus	Little brown bat		1
Vespertilionidae	Myotis	leibii	Small-footed myotis		1
Vespertilionidae	Lasionycteris	noctivagans	Silver-haired bat		1
Vespertilionidae	Eptesicus	fuscus	Big brown bat		1
Vespertilionidae	Lasiurus	borealis	Red bat		1
Vespertilionidae	Lasiurus	cinereus	Hoary bat		1
Leporidae	Sylvilagus	floridanus	Eastern cottontail	B	1,2,3
Leporidae	Sylvilagus	audubonii	Desert cottontail	B	1,2,3,4
Leporidae	Lepus	townsendii	Whitetail jackrabbit	B	1,2,3
Leporidae	Lepus	californicus	Blacktail jackrabbit	B	1,2,3,4
Sciuridae	Spermophilus	tridecemlineatus	13-lined gr.squirrel	B	1,2,3,4
Sciuridae	Spermophilus	spilosoma	Spotted gr.squirrel	B	1,2,3
Sciuridae	Cynomys	ludovicianus	Black-tail pr.dog	B	1,2,4
Sciuridae	Sciurus	niger	Fox squirrel	B	1,2,3
Sciuridae	Eutamias	minimus	Least chipmunk	B	2
Sciuridae	Spermophilus	variegatus	Rock squirrel	B	2
Geomyidae	Thomomys	talpoides	North.pocket gopher	B	1,2
Geomyidae	Geomys	bursarius	Plains pocket gopher	B	1,2,3
Heteromyidae	Perognathus	fasciatus	Olive-bk pock.mouse	B	1,2
Heteromyidae	Perognathus	flavescens	Plains pocket mouse	B	1,2,3
Heteromyidae	Perognathus	flavus	Silky pocket mouse	B	1,2,3
Heteromyidae	Perognathus	hispidus	Hispid pocket mouse	B	1,2,3
Heteromyidae	Dipodomys	ordii	Ord's kangaroo rat	B	1,2,3,4
Castoridae	Castor	canadensis	Beaver	B	1,2
Cricetidae	Reithrodontomys	montanus	Plains harvest mouse	B	1,2
Cricetidae	Reithrodontomys	megalotis	West. harvest mouse	B	1,2,3
Cricetidae	Peromyscus	maniculatus	Deer mouse	B	1,2,3
Cricetidae	Onychomys	leucogaster	N.grasshopper mouse	B	1,2,3
Cricetidae	Microtus	pennsylvanicus	Meadow vole	B	1,2,3
Cricetidae	Microtus	ochrogaster	Prairie vole	B	1,2,3
Cricetidae	Ondatra	zibethicus	Muskrat	B	1,2,3,4
Muridae	Mus	musculus	House mouse	B,I	1,2
Muridae	Rattus	norvegicus	Norway rat	B,I	1,2
Zapodidae	Zapus	hudsonius	Meadow jumping mouse	B	1,2
Erethizontidae	Erethizon	dorsatum	Porcupine	B	1,2,3
Canidae	Canis	latrans	Coyote	B	1,2,3,4
Canidae	Vulpes	vulpes	Red fox	B	1,2,3
Canidae	Vulpes	velox	Swift fox	B	1,2,3
Canidae	Urocyon	cinereoargenteus	Gray fox	B	1,2,3
Procyonidae	Procyon	lotor	Raccoon	B	1,2,3
Mustelidae	Mustela	erminea	Ermine		1
Mustelidae	Mustela	frenata	Long-tailed weasel	B	1,2,3
Mustelidae	Mustela	nigripes	Black-footed ferret	E	1,2,3
Mustelidae	Mustela	vison	Mink	b	1,2
Mustelidae	Taxidea	taxus	Badger	b	1,2,4
Mustelidae	Mephitis	mephitis	Striped skunk	B	1,2,3
Mustelidae	Spilogale	putorius	Spotted skunk	B	1,2
Felidae	Felis	rufus	Bobcat	B	1,2

Family	Genus	Species	Common Name	Status*	Source Document**
Cervidae	Odocoileus	hemionus	Mule deer	B	1,2,3,4
Cervidae	Odocoileus	virginianus	White-tailed deer	B	1,2,3,4
Antilocapridae	Antilocapra	americana	Pronghorn	B	1,2,3

* Status:B=Definite breeder b=Likely breeder E=Endangered G=Game I=Introduced M=Migrant n=Non-breeder R=Resident W=Winter visitor

**Source Document: 1=EIA.1976.Fairbanks,R.L. & J. Kolmer. 2=Colorado Division of Wildlife Latilong Studies 3=Barr Lake Mammal Checklist 4=Observed on site 5=Information from D.Thorne,PMO,RMA.

APPENDIX B

COMMENTS AND RESPONSES TO THE TASK 9 DRAFT FINAL TECHNICAL PLAN, NOVEMBER 1985 AND TASK 9 DRAFT FINAL PHASE II TECHNICAL PLAN, AUGUST 1986

The Task 9 Draft Final Technical Plan was distributed on November 27, 1985 to all organizations and the State (OAS). Comments were received from Shell Oil Company (Shell) on December 19, 1985. No comments were received from the Colorado Department of Health (CDH) or the U.S. Environmental Protection Agency (EPA).

The Task 9 Draft Final Phase II Technical Plan was distributed on August 27, 1986 to all OAS. Comments were received from Shell on September 26, 1986, from CDH on December 9, 1986, from the Colorado Division of Wildlife on January 22, 1987, and from the U.S. Fish and Wildlife Service on February 3, 1987. No comments were received from the EPA.

All specific written comments and responses are contained in the following appendix.

Shell Oil Company

One Shell Plaza
P.O. Box 4320
Houston, Texas 77210

December 19, 1985

Commander
USATHAMA
Building E4435, 2nd Floor
AMXTH-AS-O/Mr. Don Campbell
Aberdeen Proving Ground, MD 21010-5401

Dear Mr. Campbell:

We have reviewed the referenced plan you provided us for comment. We appreciate the opportunity to interact on this study and hope the attached comments prove beneficial to the overall study.

As you indicated in your letter of November 27, 1985, we hopefully will be able to merge our respective plans. However, I am concerned that this may prove difficult to accomplish if the results of the first meeting between our respective contractors are any indication. It is my understanding the discussion was focused on identifying areas of agreement, rather than attempting to merge the programs. Maybe the meeting that was held December 12 resulted in greater progress.

As I stated during our meeting at the RMA, and confirmed in our subsequent telephone conversation, we need to obtain agreement by January 1, 1986 or our contractor will have to initiate the field program they have outlined. Needless to say, this should not preclude our merging of the plans where appropriate after that date. However, I must emphasize we will not be in a position to delay the start beyond January 2, 1986.

We look forward to developing a mutually agreeable program in this area. After your organization has had an opportunity to review the attached comments, perhaps further progress will be made towards our common goal.

Very truly yours,

C.K. Hahn

C. K. Hahn, Manager
Denver Site Project

CKH:ajg

Attachment

cc: See attached

BIHM8535303

cc: (w/attachment)
Mr. E. J. McGrath
Holme Roberts & Owen
1700 Broadway, 18th Floor
Denver, CO 80290

Mr. Tom Bick
Land & Natural Resources Division
U.S. Department of Justice
P. O. Box 7415
Benjamin Franklin Station
Washington, D.C. 20044-7415

RESPONSES TO SHELL OIL COMPANY COMMENTS ON THE DRAFT FINAL BIOTA ASSESSMENT TECHNICAL PLAN NOVEMBER 1985

General Comments

Comment 1: The Technical Plan is vague in defining specific elements. However, the document could use an edit regarding missing references and the format for in-text citations.

Response: See text.

Comment 2: We question the overall approach of the study because of its reliance on existing information concerning the presence and distribution of contaminants in the biota. The existing data were not collected for the same purposes as the present study, i.e., determining the nature and extent of injury to the biotic resources and allocating relative liability between the Army and Shell. In addition, remedial action was not a consideration during data collection, and the existing information also may be of marginal use for that purpose.

Response: Only the first phase of this assessment relied on past studies. Recent information developed as a result of contaminant assessment in all environmental media in relation to the remedial investigation have been used, as available, to develop and expanded workscope appropriate to current data needs. This potential expansion was anticipated in the original plan, but specific needs were not addressed, pending the availability of pertinent data from other tasks.

Comment 3: The plan is not organized as well as it could be. As a result, repetition occurs (e.g., discussion of Phase I field surveys), and information on a single subject (e.g., details on Phase II or chemical analysis) is spread out over several sections.

Response: Few plans are ever organized as well as they could be.

Comment 4: Several places in the plan state that organochlorines -- endrin, dieldrin, and/or aldrin --showed elevated values in tissue sampled during previous Army studies. In nearly every instance, no mention is made of the groups of substances for which analysis was conducted nor whether any Army originated compounds were included in the tissue analysis. In the interest of not biasing the Technical Plan, the preceding omissions should be corrected.

Response: Sources of the information used to present this information are readily available for examination. A

detailed discussion of purpose and methods of previous investigations is not appropriate in this technical plan.

Comment 5: The draft is incomplete without a detailed schedule and listing of intended products and outputs. For example, no details are given regarding tissue sampling for chemical analyses; on what species or by what methods.

Response: A detailed schedule and end products were not possible at the time this technical plan was prepared, due to uncertainties regarding what, if any, additional work would be needed. The possibility of additional work, however, was indicated.

As you are undoubtedly aware, chemicals and species for analysis are regularly discussed in the Biota MOA Subcommittee meetings in which Shell, MKE, ESE, U. S. Army, and other parties participate.

Comment 6: The level of detail presented in the Biota Technical Plan does not allow a review of the methods ESE will use to obtain their field data in Phase I and Phase II. Specifically where, when, and how will field surveys be carried out in Phase I? At least some of these surveys (e.g., radiotelemetry and small mammal live-trapping) are already in progress, yet details were not provided in the ESE study plan, nor was Shell afforded the opportunity to comment on the work before it began or invited to observe the field surveys. MKE, on the other hand, was required to provide details of their field program for USATHAMA review prior to starting field work.

Response: The referenced radiotelemetry studies were conducted as part of the Offpost Contamination Assessment and not as part of this assessment at this point in time. Copies of the technical plan for the radiotelemetry work were provided to Shell and other parties for review and comment prior to any field work. The small mammal live-trapping was for cottontails to be fitted with radiotransmitters as part of the aforementioned offpost study. No request was received from Shell or MKE for observing these field studies.

Specific Comments

Comment 1:
p. 1-3, para. 3

Were any substances besides dieldrin and other organochlorine compounds, (for example, mercury and arsenic), analyzed for in fish and birds? If analysis for chemical agents was not included in the tissue samples, it should be so stated. The same procedure should be followed throughout the Technical Plan.

Response: We do not believe that detailed discussions of methods and objectives of past investigations are pertinent to an evaluation of this technical plan. However, the studies referenced in this plan are available for public review, if you choose to do so.

Comment 2:
p. 1-4,
section 1.2.1,
sentence 1

We feel that grassland is too broad a classification because annual weedy grasses and forbs provide a different quality and type of habitat than native perennials. Also, shrubs do not fit well into the three ecosystems delineated by ESE.

Response: This comment has been addressed in the updated (Phase II) version of the biota assessment technical plan, dated August 1986.

Comment 3:
p. 1-5, para 2,
sentence 4

Eighteen species of ducks have been recorded on the RMA along with five accidental or stray species according to the Installation Assessment of Rocky Mountain Arsenal Records Evaluation Report No. 107, Vol. 1. What other sources were used to obtain the twenty-seven species inhabiting RMA? Include as a reference. Also, what is meant by "inhabiting"?

Response: See text for changes, and see Appendix A of Phase II for citations and updated list of species.

Comment 4:
p. 1-6,
section 1.3,
paragraph 2,
sentence 2 and 3

No reference in the bibliography for Thomas, et. al. (1979), Boyce Thompson Institute (1976), Denver Wildlife Resource Center (1962), or Dugway Proving Ground (1975).

Response: See text and reference for correction.

Comment 5:
p. 1-6,
section 1.3,
paragraph 2,
sentence 2

An Army compound such as DIMP should also be mentioned along with organochlorine compounds as having adverse affects since it is mentioned in Palmer, et. al. (1979).

Response: Comment acknowledged.

Comment 6:
p. 1-7, para. 4

MKE requests a copy of the Offpost Contamination Assessment Program.

Response: We do not understand why this request was included as a comment from Shell. MKE should request their copy from Shell.

Comment 7:
p. 1-9, para. 3
section 1.4,
sentence 3

This sentence leaves the reader curious and "in limbo". Briefly explain the procedure.

Response: The referenced document is available for public review. No additional explanation is necessary.

Comment 8:
p. 1-10, para. 2

It is stated that many studies on the biological effects and RMA contaminant levels in biota have been conducted. Are these data almost exclusively for Shell compounds? Is the unavailable information on dose levels, physiological effects, etc., mentioned in Sentence 2 applicable to Army-originated compounds alone? If so, this should be stated so the reader does not make incorrect conclusions from the general statements.

Response; The information used was intended to provide a general background. A detailed treatment of all available information is inappropriate as part of the technical plan but will be covered in the resulting reports.

Comment 9:
p. 1-10, para. 2
sentence 3 and
subsequent
locations

Does "Dugway Proving Ground, 1973" need to be changed to "U.S. Army, Dugway Proving Ground, 1973"?

Response: Yes.

Comment 10:
p. 1-10, para. 3,
sentences 3 and 4

Were any Army originated compounds present in detectable levels or even included in the analysis?

Response: Statement is correct as it stands. The referenced documents are available at the RIC.

Comment 11:
p. 1-11, para. 2

A "lethal level of 0.7-0.8 ppm for birds" seems low. The reference should be checked. Lindner, et. al., 1970, states the following: "It appears that a level of 3 to 4 ppm in the brain of a pheasant would indicate that death was caused by dieldrin". (Lindner, et. al., 1970). Residues in the brain of pheasants given dieldrin. J. Wildl. Mgt 34(4):954-956.

Response: The reference cited was checked as requested and found to be correct.

Comment 12:
p. 1-11, para. 3
sentences 1 and 2

Organochlorines - same as above comments.

Response: The reference cited was checked as requested and found to be correct.

Comment 13:
p. 1-12, para. 3
sentence 1

Should "Upper" be added to "Derby Lake"?

Response: Yes.

Comment 14:
p. 1-12, para.3
sentence 2

No comment is made about the state of knowledge concerning pathways of bioconcentration of chemical agents and their precursors and derivatives. If not much is known, it should be so stated.

Response:

See text.

Comment 15:
p. 1-13, para. 1
section 1.5.1,
sentence 2

Who is performing these studies, why, for whom, where, and on what biota components?

Response:

These studies were being conducted by Dave Thorne and included the regular sampling of a variety of biota under the Army's agreement for biota monitoring with the U. S. Fish and Wildlife Service. Details of the program are available from the Program Manager's Office at Rocky Mountain Arsenal and from documents available in the Rocky Mountain Information Center (RIC) at Rocky Mountain Arsenal.

Comment 16:
p. 1-13, para. 2,
section 1.5.1,
sentence 1

Why are wildlife species to be studied only those posing a direct exposure hazard to humans? Other species not directly in the human food chain may be important in determining natural resources injury.

Response:

The overall biota assessment here addresses species in the food chain to humans and includes other species of ecological concern, as well. This task includes a broader range of biological assessment that was included in the original offpost studies. Other potential effects were not considered in the initial study, pending the development of recent information on the distribution of contaminants in other environmental media (e.g. soil, surface water). The biota assessment currently encompasses all other potential effects from all RMA chemicals.

Comment 17:
p. 1-13, para. 2,
section 1.5.1,
sentence 3

Why are other potential effects not considered?

Response:

Other effects are addressed in the current techncial plan.

Comment 18:
p. 1-14, para. 1,
sentence 1

"Shell Wildlife Studies team" should be changed to "Morrison-Knudsen Engineers Wildlife Biologists".

Response:

See text.

Comment 19: p. 1-14, para. 1, section 1.5.2, sentence 3	How will the screening be preformed?
Response:	Details of the screening process are described in the updated (Phase II) Draft Final Technical Plan, dated August 1986.
Comment 20: p. 1-15, para. 1	When will the field survey be done? Are the existing surveys of sufficient detail to do what you say?
Response:	The survey involved "ground-truthing" visits to verify conditions/vegetation types reported in earlier studies and to document any changes (e.g. burning, plowing, etc.) of recent origin. The presence of plant and animal species was also noted in order to verify or note additions to species lists already developed for RMA. The surveys were of sufficient detail to achieve the stated objectives.
Comment 21: p. 1-15, para. 2	Comprehensive food web - When?
Response:	A discussion of the comprehensive food web is included in section 2.0 of the updated (Phase II) Draft Final Biota Assessment Technical Plan, dated August 1986.
Comment 22: p. 16, para. 1	Does CERCLA stipulate unrestricted use?
Response:	No.
Comment 23: p. 2-1, para. 1 sentence 4	What are the several parts in the preliminary biota assessment?
Response:	The several parts include an evaluation of sites of contamination, an evaluation of chemical contaminants of concern, a pathways analysis for key species and major ecosystems, and a proposed plan for obtaining any additional pertinent information.
Comment 24: p. 2-1, para. 2 sentence 2	Are the secondary contamination impacts going to be studied by ESE?
Response:	Yes, as part of the offpost endangerment assessment under the Remedial Investigation for RMA.
Comment 25: p. 2-2, para. 1, section 2.1.2, sentence 4	Good quality distribution and population density information is limited for the RMA.
Response:	Comment acknowledged.

Comment 26:
p. 2-2,
section 2.1.2

Are the existing data adequate to assess injury to biota and to assign responsibility to the appropriate party in an unbiased manner?

Response:

Probably not.

Comment 27:
p. 2-3

What is the relationship between the EPA and USATHAMA areas? Is Sand Creek being studied as a part of this biota assessment?

Response:

Sand Creek is being investigated by EPA; the Army is investigating RMA and the offpost study area (see Figure 2.1-1).

Comment 28:
p. 2-4, para. 1
sentence 1

180,000 documents related to fish and wildlife?

Response:

Not necessarily all.

Comment 29:
p. 2-4, para. 4

See general comment number 4, supra.

Response:

Comment acknowledged and addressed under general comment no. 4.

Comment 30:
p. 2-5, para. 1,
section 2.1.3,
sentence 1

What are the details on the field survey (where, what species specifically, what methods, when)?

Response:

The areas of investigation are shown in Figure 2.1-1. Key species are defined in section 2.3.1. Methods include direct observation using binoculars and spotting scopes, and limited collection of voucher specimens (plants only). No trapping was planned and none was conducted as part of this survey. Detailed survey methods were not described because detailed survey methods were not used.

Comment 31:
p. 2-5,
section 2.1.3,
sentence 2,
p. 2-6,
para. 2 and 3

Fall is not a preferred time to identify grasses or forbs. Will other vegetation surveys be done to complete this aspect?

Response:

Yes. See section 3.1 of updated (Phase II) Draft Final Biota Assessment Technical Plan, dated August 1986.

Comment 32:
p. 2-6, para. 2,
sentence 1

Is the field survey complete at this time? Certainly the methods for these could have been presented in this Technical Plan.

Response:

Yes, the survey has been made. No specific additional methods were used.

Comment 33:
p. 2-6, para. 3

The Army intends to do the field study to coincide with the fall migration of waterfowl and other birds. Why are migratory waterfowl being surveyed, since the source of contamination could have been anywhere along their migratory route? The value of surveying migratory birds would be as an indicator of the use of the RMA as a wildlife habitat.

Response:

It is inappropriate under the existing MOA to ask a question regarding interpretation of the data collected.

Comment 34:
p. 2-6, para. 3
Sentence 2

Morrison-Knudsen should be corrected here and elsewhere to read "Morrison-Knudsen Engineers" or "MKE". Also, Holme Roberts & Owen (HRO) is the client of MKE, and Shell is the client of HRO. MKE was not allowed to collect plant museum specimens from RMA by USATHAMA. Only vegetation types were mapped; therefore, "detailed information on plant species" is not available from MKE.

Response:

See text throughout document.

Comment 35:
p. 2-6, para. 4

Only very general statements were made about the field study methods. Since these were already nearly completed at the time of the study plan, the following information was definitely available for the driving and walking surveys, live-trapping, and sign searches: Where, using what methods, when, over how many days, by how many biologists. The plan says that "...large Tomahawk live traps may be used..." but, in fact, these types of traps were observed near First Creek north of the North Plants in August. Is the live-trapping statistically valid if for the purpose of population estimates?

Response:

The study methods as described above were very general. Field studies were NOT "already nearly completed at the time of the study plan". The surveys were conducted throughout the Arsenal on adjacent areas and involved approximately 2-3 person-weeks of work by two biologists.

The use of live traps observed near First Creek in August were for the purpose of catching cottontails as part of the Offpost biota studies and not as part of the studies described in this technical plan. The methods for the cottontail study were provided to Shell as part of the offpost technical plan, well in advance on this work.

Comment 36:
p. 2-7, para. 1

Why did you assume that MKE will be conducting field aquatic studies when the plan has not been submitted to the Army?

Response:

We were orally informed by MKE of their intention to conduct aquatic studies of the Lower Lakes. This information turned out to be correct.

Comment 37: p. 2-7, para. 2 sentence 1	Limited field studies indicate that bias will likely be present. Where, when, and how were these done? Also, it states that no sampling will be necessary for fish, aquatic invertebrates or vegetation for most water bodies. References verifying this assertion should be included so that Shell can review them to determine their adequacy.
Response:	The purpose and general scope of the "limited field studies" was described in the technical plan and addressed further in the responses to previous questions (above). We are aware of the "thorough literature survey" being conducted by or under the supervision of MKE in relation to this project and refer you to the RIC at RMA for pertinent references on the lake ecosystems.
Comment 38: p. 2-7, para. 2 sentence 2	"Safety equipment" should be substituted for "safety attire" since an APR would also be worn into an area with a respiratory hazard.
Response:	Comment noted.
Comment 39: p. 2-7, section 2.2	With the level of detail given it is difficult to determine the applicability of criteria development for contamination loading.
Response:	Comment acknowledged.
Comment 40: p. 2-8, section 2.3	It is not clear from the description of the contamination assessment section in Phase I whether there actually will be chemical analysis conducted of all the resources (e.g., soil, biota, ground water) potentially impacted by chemicals present on the RMA.
Response:	There will be chemical analysis of all the resources (e.g. soil, biota, ground water), but not under this task. Contaminant analysis of biota samples will occur in Phase II of the Biota Assessment.
Comment 41: p. 2-9, para. 1	Chemical contaminants in what?
Response:	Contaminants in soil, ground water, surface water, and air will be obtained from other tasks.
Comment 42: p. 2-9, para. 1 sentence 4	Will all seven factors be studied in Phases I and II for biota? If so, that is a very wide scope of work.
Response:	These factors will be investigated to the extent possible, based on the availability of suitable methods and on a potential for the effect of these factors in Arsenal biota. The scope of work is potentially very wide.

Comment 43:
p. 2-9, para. 2
sentence 1

Are the "three categories mentioned above" the "three main areas" on the bottom of Page 2-8 and top of Page 2-9? Please clarify.

Response:

Yes.

Comment 44:
p. 2-10, para.1

Why do the criteria here contain three additions and one omission compared with those on Page 2-6? Also, is laboratory testing planned for some species - how will it be incorporated with the rest of the work?

Response:

The "omission" referred to in this comment is for domestic animals that do not need to be inventoried at RMA because there are none. The three "additions" provide more detail on the major criteria stated on page 2-6. The additional detail (page 2-10) will be possible as a result of information obtained in Phase I following the field surveys, but information on the major categories can be obtained during the general surveys. These two lists are consistent.

Comment 45:
p. 2-11,
section 2.3.4,
sentence 4

If in food web analysis "incomplete data sets can lead to a functional understanding of the biological systems of an area", why can this concept not also apply to population estimates (i.e., top of Page 2-11).

Response:

This concept can apply to population estimates. There is a difference between providing "a functional understanding of the biological systems" and providing "reliable annual population estimates" that we thought was obvious.

Comment 46:
p. 2-12, para. 3
sentence 2

Offpost studies are indicated. What relevance do they have? This should be clearly indicated.

Response:

As previously indicated, the offpost studies are not part of this technical plan.

Comment 47:
p. 2-12, para. 1
sentence 4

How will the lack of hazard of a contaminant to biota be determined since little is known about the low level effects of many Army compounds. For which contaminants does ESE believe there is good information?

Response:

These questions require interpretive answers which are not appropriately addressed at this time.

Comment 48:
p. 2-14, para. 1

Are any defensible HSI models available for use on key RMA species? Does ESE think that HSI models can be developed for the remaining key species economically considering the vast amount of work required for each model? In addition, how can determining the potential carrying capacity for an area as small as RMA assist in determining injury to biota when that factor is difficult to relate to chemical contamination?

<u>Response</u>:	Suitable HSI models exist for some key species. A determination on what, if any, additional work will be addressed under Phase II and subsequent studies, pending the results of current and proposed biota investigations.
<u>Comment 49</u>: p. 2-15, para. 1	The Army indicates it will look at Section 36, Basin F, lower lakes and portions of the South Plants in the Phase II study. They make no mention of the North Plants (GB) area, wheat rust area and the many sites they stored or disposed of a variety of their toxic chemicals. For a damage assessment study to be objective areas impacted solely by the Army also must be evaluated.
<u>Response</u>:	All potential sites of contamination on RMA will be considered for investigation. This technical plan is for Remedial Investigation requirements under CERCLA and does not specifically address natural resource damage assessment as suggested in your comment.
<u>Comment 50</u>: p. 3-1, section 3.1.1	HEP may not be suitable for evaluating biota at RMA. This technique is most suitable for developing baseline environmental data typical of preconstruction or pre-operation activities, therefore it may be hard to apply to RMA.
<u>Response</u>:	Comment acknowledged. The potential application of HEP in the biota assessment at RMA has not yet been determined.
<u>Comment 51</u>: p. 3-1, section 3.1.1 paragraph 2 1st bullet	Will MKE biologists not be considered for inclusion on the assessment team? In implementing HEP, this assessment team usually chooses the evaluation species, but it appears that this has already been done. How closely will the HEP be adhered to?
<u>Response</u>:	MKE biologists will be considered for inclusion in the assessment team. Selection of evaluation species for purposes of HEP has not been done. If used, the HEP will be followed as closely as possible.
<u>Comment 52</u>: p. 3-2	The source for Figure 3.1.1 should be referenced as Habitat Evaluation Procedures Workbook, Page 102.
<u>Response</u>:	See Figure 3.1-1.
<u>Comment 53</u>: p. 3-4, section 3.1.4	States that information on dose levels, pathways, movements and levels of selected contaminants in the biota will be obtained (from the literature I assume). Is such data available for Army compounds?
<u>Response</u>:	Some data are available for Army chemicals.

Comment 54: p. 4-1, section 4.1, paragraph 1, sentence 3 and 4	Does this mean that heavy metals will be tested for in Phase I?
Response:	No.
Comment 55: p. 4-1, section 4.1, para. 3, sentence 2	What is meant by the phrase "...'fingerprint' of contamination in the tissues and/or organisms to be analyzed?
Response:	The word "fingerprint" means an indication of occurrence.
Comment 56: p. 7-2, table 7.1.1	Where does this list of contaminants of concern come from? Is it the official Army list to be used for analysis of samples? Where is page 3 of 3?
Response:	This list of chemicals was developed during preliminary discussions of contamination at RMA. There is no page three of three, or reference to one.
Comment 57: p. 7-4, para. 1	Will ESE personnel conducting biota sampling have physical examinations both before and after conducting field work? Who will decide the level of protection for entry into restricted areas?
Response:	Details of the safety plan included responses to these questions and are addressed in the updated (Phase II) technical plan dated August 1986. Details of safety were not believed necessary, inasmuch as no field sampling had been determined at the time of development of this plan.

Shell Oil Company

One Shell Plaza
P.O. Box 4320
Houston, Texas 77210

September 26, 1986

Mr. Donald Campbell
Environmental Engineering Division
Department of the Army
Program Manager, Rocky Mountain
Arsenal Contamination Cleanup
Aberdeen Proving Ground, MD 21010-5401

Dear Mr. Campbell:

We have reviewed the Draft Final Phase II Rocky Mountain Arsenal Biota Assessment Technical Plan of August 1986 as requested, and find that, in general, the draft technical study plan is well written and organized, and the technical approach, which it outlines, is consistent with the Biota Assessment Committee (BAC) process. However, we have some concerns with the overall study plan.

1. The tissue analysis is limited to organochlorine pesticides, mercury and arsenic. These are not the only chemicals of concern at the Arsenal. Chemical analysis also should be conducted on other contaminants, such as diisopropylmethylphosphonate (DIMP), dithiane and oxathiane.

2. We question the value of the description of the biota in the introduction section, since there are numerous inaccuracies, which underscores the limited usefulness of the available information on the biota at the RMA.

3. We also question whether the limited number of sites proposed for tissue sampling is adequate.

4. In addition, the use of the term "contamination" should be defined. It is not clear whether it means concentrations above detection limits, background levels or U.S. Food and Drug Administration (FDA) levels.

5. There also are numerous spelling errors in the text and the species lists, which should be corrected.

Specific comments on the draft study plan are provided in the attachment.

We appreciate the opportunity to provide comments on this study plan and hope that they will prove useful to you.

Very truly yours,

C. K. Hahn

C. K. Hahn, Manager
Denver Site Project

MEF:bas

Attachment

cc: Mr. E. J. McGrath
Holme Roberts & Owen
1700 Broadway, 18th Floor
Denver, CO 80290

Mr. Tom Bick
Land & Natural Resources Division
U.S. Department of Justice
P.O. Box 7415
Benjamin Franklin Station
Washington, DC 20044-7415

Dr. Allen Crockett
Morrison-Knudsen Engineers
1700 Broadway
Denver, CO 80290

Dr. Douglas Reagan
Environmental Science and Engineering, Inc.
7332 South Alton Way, Suite H
Englewood, Colorado 80122

Ms. Kathi Demarest
Colorado Division of Wildlife
6060 Broadway
Denver, Colorado 80216

Mr. Phil Hegeman
Water Quality Control Division
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

RESPONSES TO SHELL OIL COMPANY COMMENTS ON THE DRAFT FINAL PHASE II BIOTA ASSESSMENT TECHNICAL PLAN AUGUST 1986

General Comments in Cover Letter

Comment 1: The tissue analysis is limited to organochlorine pesticides, mercury and arsenic. These are not the only chemicals of concern at the Arsenal. Chemical analysis also should be conducted on other contaminants, such as diisopropyl-methylphosphonate (DIMP), dithiane and oxathiane.

Response: We agree that other chemicals are of concern. However, only five chemicals currently meet the criteria for analysis in biological tissues at this time. The sampling program is dynamic, and new chemicals may be added at any time, if there is sufficient justification for their inclusion. DIMP, dithiane, and oxathiane are still under consideration for tissue analysis.

Comment 2: We question the value of the description of the biota in the introduction section, since there are numerous inaccuracies, which underscores the limited usefulness of the available information on the biota at the RMA.

Response: The descriptive information provided in the introduction was to provide background. The Phase II program is in part designed to collect information on the "inaccuracies" apparently identified in this section. The information base used to identify these is presumed to be field studies and literature surveys prepared by Shell contractors. Much of this information base was promised and should have been provided to the Army, prior to the development of much of this section, thus precluding many of Shell's specific comments.

Comment 3: We also question whether the limited number of sites proposed for tissue sampling is adequate.

Response: The list of areas for contaminant sampling is dynamic and subject to change, pending the availability of pertinent information indicating the need for expanding the program. Specific constructive suggestions are always welcome and could be made in the context of the Biota MOA Subcommittee meetings.

Comment 4: In addition, the use of the term "contamination" should be defined. It is not clear whether it means concentrations above detection limits, background levels or U.S. Food and Drug Administration (FDA) levels.

Response: The word "contamination" as used herein is used in accordance with its dictionary definition and has not specific contextual meaning.

Comment 5:	There also are numerous spelling errors in the text and the species lists, which should be corrected.
Response:	The typographical errors referred to are, in part, a result of the haste with which this document was prepared in order to be available for comment by involved parties as quickly as possible. We were attempting to accommodate Shell and other reviewers.

Specific Comments

Comment 1: p. 1-3, para. 5	The extensive weedy habitats as well as upland shrubs and locust thickets also should be mentioned here.
Response:	See text, p. 1-3.
Comment 2: p. 1-4, para. 2	The correct spelling of the pheasant is "ring-necked pheasant".
Response:	See text, p. 1-4.
Comment 3: p. 1-6, para. 2	Limestone is a minor rock type in sediments of the study area and therefore should not be listed first. The geologic data also show that Quaternary alluvium averages 30-40 feet, not 10-20 feet, in thickness.
Response:	See text.
Comment 4: p. 1-6, para. 3	The correct spelling of the word is "volcaniclastic".
Response:	See text change, p. 7.
Comment 5: p. 1-8, para. 4	The term "non-native herbaceous" is a poor choice, since crested wheatgrass also is a non-native herbaceous species.
Response:	See Text.
Comment 6: p. 1-8, para. 5	Hairy golden aster and western ragweed are common forbs in the late summer. The common forbs in the spring and early summer also should be mentioned.
Response:	Comment noted.
Comment 7: p. 1-10, Figure 1.2-2	a) The map shows large areas as "non-native herbaceous" vegetation. Much of this actually is "crested wheatgrass" as mapped by MKE, although the Army claims to have based their map on MKE's data. b) The term "woody shrubs" should be modified since all shrubs are woody be definition. "Upland shrubs" or "shrub-grassland" would be better choices.
Response:	See text and Figure 1.2-2.

Comment 8:
p. 1-11, para. 2

a) The thickets are New Mexico locust, not black locust, and they are found primarily at the southern tier of the RMA. b) "Dense willow thickets" are mentioned but they are not identified.

Response:

For descriptive purposes, "willow" is adequate. More detailed identifications require inflorescences for accurate keying.

Comment 9:
p. 1-12, para. 2

Northern pike should be included in the description of the gamefish present.

Response:

See text.

Comment 10:
p. 1-12, para. 5

a) Brewer's sparrow and the lark bunting are not common breeders, while the vesper sparrow and grasshopper sparrow are common breeders and should be mentioned here. b) The common redpoll and lapland longspur are not dominant winter resident, whereas water pipits are common winter residents and should be mentioned here. c) The mourning dove should not be included in this sentence, since it is not nearly as common as the other birds mentioned.

Response:

(a) The Brewer's sparrow and lark bunting are described by the Colorado Division of Wildlife as "definite breeders" in an area which includes RMA. (CDOW 1982a). The vesper sparrow does breed in the area but the names mentioned were not intended to be inclusive, only representative. The grasshopper sparrow is considered by the Division of Wildlife to be "unusual" in abundance. If MKE observations suggest differently, perhaps this information could be forwarded to the Division of Wildlife for their use. Specific comments such as this are apparently based on field studies conducted by MKE for Shell, and the information was not provided to the Army or ESE.

(b) See text. Water pipits are classified as migrants by the Division of Wildlife. If MKE has data indicating that pipits are winter residents, perhaps the CDOW should be informed.

(c) It has been our observation that mourning doves are very common at RMA. Without reliable census data we cannot place them on an abundance scale relative to the other birds mentioned.

Comment 11:
p. 1-13, para. 1

a) The correct name is American tree sparrow. b) Yellow warblers are very common breeders in the woodland habitats and should be mentioned here. c) The dark-eyed junco was not common last winter and should not be placed in the same category as the other birds listed in this sentence.

Response:

(a) See text, p. 1-13.

(b) See text, p. 1-13.

(c) The Division of Wildlife considers the dark-eyed junco to be a "common" or "fairly common" winter resident in the RMA vicinity. Their evaluation is based on several years of data, not just one winter's observation.

Comment 12:
p. 1-13, para. 3

a) Brewer's sparrow, sage thrasher, mockingbird, and tree swallow were not observed to be breeders. b) The grasshopper sparrow is one of the most widespread and abundant species on the eastern plains and is inappropriate for inclusion in this paragraph.

Response:

(a) CDOW (1982a) considers all of these birds to be definite breeders within the area including RMA. The fact that MKE did not observe them breeding does not provide adequate proof that breeding did not occur on RMA.

(b) The grasshopper sparrow is considered "rare" or "unusual" throughout the area (CDOW 1982a). If MKE has information to the contrary, it should be provided to the CDOW for their use.

Comment 13:
p. 1-13, para. 4

The correct name is northern harrier, not marsh hawk.

Response:

See text, p. 1-13.

Comment 14:
p. 1-14, para. 1

a) The rodents are voles, not moles. b) Fox squirrels have not been observed.

Response:

(a) See text p. 1-14.

(b) Comment is in error. ESE has observed fox squirrels on RMA.

Comment 15:
p. 1-14, para. 2

White-tailed jackrabbits also are present and should be mentioned.

Response:

No source of information is provided for this assertion.

Comment 16:
p. 1-14, para. 3

The present population of mule deer is estimated to be 200 animals. In addition, more than 25 white-tailed deer have been observed at the RMA.

Response:

No source of information is provided for this assertion.

Comment 17:
p. 1-14, para. 5

a) By what criteria are the prairie falcon, ferruginous hawk and western burrowing owl considered rare? A reference should be cited. b) Who reported the spotted owl?

Response:

See text, p. 1-14.

<u>Comment 18</u>:
p. 1-15, last para.
p. 1-16, para. 1

The chemical analyses conducted on dead or dying birds or those showing erratic behavior did not include a myriad of other toxicants known to occur at the RMA. These analytical shortcomings and lack of conclusiveness should be noted.

<u>Response</u>:

The information presented is correct as stated. Recent studies of the Lower Lakes did not find many of the "myriad of other toxicants" to which you refer. Your comments are acknowledged.

<u>Comment 19</u>:
p. 1-18, para. 1

While statistically valid results may not be required by the NCP, they are required by the final rule on natural resource damage assessment to confirm injury to natural resources (51 FR 27674).

<u>Response</u>:

At the time that this plan was assembled, the Natural Resource Damage Assessment regulations were in draft form. Even in this form, there is no reference addressing the need for statistical validity in food chain analysis. As stated previously in this plan, this technical plan is designed to fulfill the requirements of Remedial Investigation and is not necessarily adequate for compliance with Natural Resource Damage Assessment.

<u>Comment 20</u>:
p. 1-18, para. 2

The federal register issue in which the final rule is published is volume 51, not 50.

<u>Response</u>:

See text, p. 1-18.

<u>Comment 21</u>:
p. 2-5,
Figure 2.1-3

The figure refers to 'Derby Lake" whereas the text on p. 2-7 and other pages refers to "Lower Derby Lake".

<u>Response</u>:

See Figure 2.1-3.

<u>Comment 22</u>:
p. 2-7, last para.

Lake Ladora is not a natural lake. It was constructed by farmers. Lower Derby Lake also was constructed prior to 1937.

<u>Response</u>:

This statement contradicts our source of information (see text), and no reference is provided.

<u>Comment 23</u>:
p. 2-11,
section 2.2

Shell presented detailed comments on July 22, 1986, regarding the chemical index in the draft final report by Geraghty & Miller, April 1986. We suggest that Shell's comments on the chemical list be reviewed.

<u>Response</u>:

We intend to evaluate these comments as part of our ongoing review of data requirements for the biota assessment.

Comment 24: p. 2-11, bullets 1-3, and p. 2-13, Table 2.2-1

It is not clear how the potential contaminants of concern (Table 2.2-1) were chosen, since they do not satisfy all the criteria on p. 2-11 (bullets).

Response:

See text for expanded explanation.

Comment 25: p. 2-13, Table 2.2-1

What is the significance of this list of potential contaminants, if only aldrin, dieldrin, endrin, mercury and arsenic will be analyzed in biota?

Response:

This list of chemicals was identified as containing the chemicals of greatest concern in the soil and ground water at RMA. We evaluated this list to determine the chemicals of greatest concern to biota at RMA, based on the criteria discussed in the technical plan and information available on the current concentration and distribution of contaminants in the abiotic environment at RMA.

Comment 26: p. 2-17 to 2-20, Table 2.3-1

The correct spellings are blue-winged teal, green-winged teal, and ring-necked duck. The correct names are American robin and northern pintail. Mistakes of this type are common throughout the text, tables, and appendix, and should be corrected.

Response:

The common names presented are not mistakes. They are only alternative names that are not currently recognized by the American Ornithologists' Union (AOU), but are in accepted usage. The common names used in this plan are listed in the appendix together with the corresponding scientific names, in order to prevent confusion. Adherence to the AOU is not necessary as the scientific names (which are standardized) were included. However, the name changes were made in order to accommodate this comment.

Comment 27: p. 2-32 to 2-33 Table 2.3-6

a) The table is well organized and the information presented with clarity. However, we question the validity of listing the "Apparent Cause of Death" because of the limited scope of tissue analyses conducted at the time. b) There are numerous nomenclatural problems that should be corrected by referring to a current AOU checklist or field guide. c) What is meant by "significant concentrations" and "high" levels of dieldrin in the tissues? These terms should be defined.

Response:

(a) Comment noted. (b) See comment for pages 2-17 through 2-20 above. (c) The column entitled "Apparent Cause of Death" presents conclusions reached in or as a result of the examination of the referenced document(s) for each species. Supporting data are found in these documents and are not presented in this table.

Comment 28: p. 2-36, para. 3	Insects are invertebrates so listing both terms is redundant.
Response:	See text for clarification.
Comment 29: p. 2-39, para. 3, bullet 2	The correct spelling is ring-necked pheasant.
Response:	See text p. 2-39.
Comment 30: p. 2-40,	a) The correct spellings of the following birds are red-winged blackbird, black-crowned night-heron. b) Badgers are not "common". c) Mule deer are browsers, not browzers.
Response:	See text for changes.
Comment 31: p. 2-41, para. 2	"Source" and "sink" food webs should be described in the order they are listed (i.e., it is not "sink and source", so "source" should be described first).
Response:	Comment noted.
Comment 32: p. 2-43, para. 1	Refers to Appendix B, which is missing in this document.
Response:	See text, Appendix B has been deleted.
Comment 33: p. 2-45	Table 2.4-2 has several spelling errors.
Response:	See Table 2.4-2.
Comment 34: p. 2-47, para. 4, p. 2-48, para. 1	The term "Lower Lakes" should perhaps be replaced with the specific lake names, since the Draft Final Source Report (Task No. 7) for Lakes Ladora and Mary would seem to refute the generalization here.
Response:	Comment noted.
Comment 35: p. 2-48, para. 3	It would be better to state that ingestion of soil is a common route of exposure, not a "standard" route; "standard" implies something a little different, such as a basis for comparison.
Response:	See text p. 2-48.
Comment 36: p. 2-48, para. 1 and 2	What is meant by "contaminated"? Does it mean above detection limits, above background level or above the FDA level?
Response:	The word "contamination" as used herein is used in accordance with its dictionary definition and has not specific contextual meaning.

Comment 37:
p. 2-48, para. 4

The term bioconcentration should not be hyphenated.

Response:

No.

Comment 38:
p. 3-1, para. 2

It should be explained why restoration and replacement will be used as the basis for determination of damages rather than diminution of use values. The final rule (51 FR p. 27723) states that the "authorized official shall select the lesser of: restoration and replacement costs; or diminution of use values as the measure of damages" except "when restoration or replacement of the injured resource is not technically feasible...." .

Response:

See text, p. 3-1.

Comment 39:
p. 3-1, para. 3

The three goals are really one-and-the-same (i.e., to determine the extent of injury) simply stated in three slightly different ways.

Response:

See text, p. 3-1.

Comment 40:
p. 3-2, para. 3

We question whether simply comparing a contaminated area onsite with "uncontaminated areas (on and off-site)" is either sufficient or even valid. How does ESE know for certain where "uncontaminated" on-site areas occur? Concurrent soil analyses? This comment holds for most of the proposed overall sampling scheme.

Response:

Uncontaminated areas onsite for biota studies were located on the basis of soil analyses for RMA contaminants described under the Army's soil tasks. Studies were conducted by ESE and Ebasco during 1985-86. Soil from all areas of the Arsenal was sampled in order to determine if contamination existed on sites other than those designated as known or potential sites on the basis of current information. Uncontaminated areas onsite were selected on this basis. This response holds true for the overall biota sampling scheme.

Comment 41:
p. 3-3, para. 2

The MKE vegetation sampling techniques are not "proposed"; they are essentially completed. Therefore, "conducted" would be a better word. The MKE scheme is not merely random; it provides very thorough coverage of the RMA. However, we have no problems with ESE collecting additional data.

Response:

See text, p. 3-3.

Comment 42:
p. 3-4,
Table 3.1-1

The numbers under soil type (e.g., 2) and transects to be sampled (e.g., 20) should be explained in the text for clarification.

Response:

See text, p. 3-4.

Comment 43: p. 3-5, para. 2
: It is stated that the transects will be located randomly. However, on p. 3-3 it is stated that transects will be located specifically in areas of contamination. Such placement of transects is not random; therefore, the statement on p. 3-5 should be modified accordingly.

Response:
: The sampling scheme is stratified random. See text.

Comment 44: p. 3-5, para. 4
: The rationale for selecting significant phytotoxic effects above a 20% level should be explained, since the 5% level is normally used as an indicator of significant differences.

Response:
: Phytotoxicity studies (RIC #81266 R8) suggest that differences of 20% in growth are probably not significant, while differences of 100% are probably very significant. The percentage figure refers to differences in growth, not statistical probability levels.

Comment 45: p. 3-5, para. 4
: The "factors other than phytotoxins that may be responsible for plant effects" should be specified.

Response:
: See text, p. 3-5.

Comment 46: p. 3-6, para. 2
: The gathering of population data for both prairie dogs and pocket gophers would not be cost-effective, since both species belong to the same trophic level and both are closely associated with the sediment.

Response:
: Both species do not inhabit exactly the same areas on RMA, therefore collection of data on both species at all sites would not be likely, but collection of data on either species would be useful. Comments on the cost effectiveness of are noted, but are not appropriate for this technical review. It is incorrect to state that both species are associated with the sediment, inasmuch as both species are terrestrial.

Comment 47: p. 3-6, para. 2
: What methods will be used for the population study?

Response:
: Various, not yet determined.

Comment 48: p. 3-6, para. 4
: The word "archived" should be substituted for "curation".

Response:
: See text, p. 3-6.

Comment 49: p. 3-7, para. 3 and 4
: Organochlorines are not the only chemicals of concern at the RMA.

Response:
: Comment noted.

Comment 50: p. 3-7, para. 4	The name is sparrow hawk, not "sparrowhawk".
Response:	See text, p. 3-9.
Comment 51: p. 3-7, para. 5	The presence of fewer nests at the RMA could be attributed to a variety of factors, including airplane noise, disking operations, and spraying with herbicides.
Response:	All factors will be considered in evaluating the data.
Comment 52: p. 3-8, para. 2	Sections 19, 20 and 29 are in the northeastern, not northwestern, corner of the RMA.
Response:	See text, p. 3-8.
Comment 53: p. 3-8, para. 2, 3, & 4	Has not all the field work described in these paragraphs been completed? The tense should be changed from future to past tense.
Response:	Work was not completed at the time this plan was written. The tense is correct.
Comment 54: p. 3-9, para. 2 & 4	Why are different number of egg and fledgling samples being collected at the RMA and control sites? Fifteen eggs are being collected at the RMA and only 10 eggs at the control site.
Response:	The differences in numbers of samples between onpost and offpost (control) areas relates to the distribution of nest boxes on RMA in relation to known/potential sources of contamination.
Comment 55: p. 3-9, para. 5	Since there can be a high degree of variability in levels of chemicals among tissue samples, compositing the samples may result in the loss of valuable information.
Response:	We agree with this comment. Compositing will be avoided, if possible. We note that MKE has proposed compositing samples in their tissue analysis program for RMA in support of Shell.
Comment 56: p. 3-10, para. 1	Why are there no nest boxes in section 34?
Response:	Rationale will be discussed in the resulting report, but is based on the approach used in an earlier U. S. Fish and Wildlife Service investigation.
Comment 57: p. 3-10, para. 4	What is meant by "elevated" levels of contaminants?
Response:	The term "elevated levels" means levels higher than those found in control samples.

Comment 58: p. 3-11, bullet 1	The terms "high volumes" and "highly toxic" should be defined.
Response:	See section 2.2 for definitions.
Comment 59: p. 3-11, para. 5	The "proposed" rule on type B natural resource damage assessments in "final".
Response:	The final rule is undergoing proposed modification.
Comment 60: p. 3-11, last para.	The sentence stating that "brain cholinesterase inhibition testing will be conducted ....if the cause of death is readily determined" needs to be clarified.
Response:	See text, p. 3-13.
Comment 61: p. 3-12, Table 3.3-1	a) Why are tissues only being analyzed for organochlorine pesticides, arsenic and mercury? b) Why are only five worms being collected? That probably is insufficient weight for chemical analysis. c) Which organ(s) will be analyzed?
Response:	(a) These compounds were selected on the basis of initial application of selection criteria and current information on RMA contaminants. The list is synamic and subject to reevaluation and subsequent modification. (b) Five composite samples of worms are being collected (see last column of Table 3.3-1. The sample sizes should be sufficient for proper chemical analysis. (c) Final decisions on what organs will be analyzed is still under discussion. Candidate organs/tissues include kidney, liver, and brain.
Comment 62: p. 3-14	The sentence should probably state "by use of at least all of....".
Response:	See text, p. 3-14.
Comment 63: p.3-14, last sentence	We look forward to seeing the results of the Army's invertebrate population studies as they will provide useful information.
Response:	Comment acknowledged.
Comment 64: p. 3-15, para. 1	When were "relatively high contaminant levels" found in aquatic snails? The 1960s or 1980s?
Response:	The relatively high contaminant levels were found in snails throughout this period. See text.
Comment 65: p. 3-15, para. 4	The dimension 25 um should be cm.
Response:	See text, p. 3-15.

Comment 66: p. 3-16, para. 2	There is no mention of statistical analysis of worm populations at the RMA and control sites to determine if significant differences occur.
Response:	Statistical methods will be presented in the report resulting from this investigation.
Comment 67: p. 3-16 to 3-17, section 3.6.2	There is no mention of statistical analysis of statistical analysis of the grasshopper data.
Response:	Statistical methods will be presented in the report resulting from this investigation.
Comment 68: p. 3-17 to 3-18,	There is no mention of statistical analysis of the data on aquatic snails.
Response:	Analysis will probably be nonparametric.
Comment 69: p. 3-18, para. 4	Organochlorine pesticides are the only chemicals mentioned. Why?
Response:	On the basis of our examination of studies conducted at RMA, organochlorines were the only chemicals associated with physical deformations (see RIC#84131R02).
Comment 70:	The terms "growers" and "vendors" needs to be clarified.
Response:	Standard dictionary definitions are used for these terms.
Comment 71: p. 4-1, para. 3	We strongly urge the Army to consider a more thorough list of analytes than just their group of five. This is bound to be criticized by the U.S. Environmental Protection Agency (EPA), Colorado Department of Health, (CDH), Colorado Division of Wildlife (CDOW), environmental groups and others. "Cost-effectiveness" and "reasonable costs" do not mean "bottom dollar".
Response:	The list of analytes for analysis in tissues was based on information available at the time that this plan was developed. As indicated in section 3 of this plan, additional data from this or other remedial investigation tasks, and from other potential sources may provide a basis for adding chemicals, sites, and/or species to the tissue analysis program. Evaluation of new data is ongoing, and progress is discussed in the Biota MOA Subcommittee meetings attended by Shell and its subcontractors, Colorado State agencies, and the Army and its subcontractors.
Comment 72: p. 4-1, para. 4	Which organs will be analyzed?
Response:	Some brain and liver definite; kidney possible.

Comment 73: Appendix A

The species list is incomplete (e.g, it does not include New Mexico locusts, which are mentioned earlier in the text as being abundant).

The bird list should not include species that theoretically might occur, but are extremely unlikely to occur at the RMA (e.g., the anhinga and wood stork). Of greater utility is a list of species observed, reported, or likely to occur (based on geographic range and habitat preference). This is especially true for various shorebirds, wading birds, and waterfowl on ESE's list, but also includes other species such as the Chihuahuan raven and Bell's vireo. Nomenclatural errors abound (e.g, northern, not common, flicker).

Response:

New Mexico locust is included in the list under genus Robinia.

Because common names are not universally standardized, it is incorrect to state that there are nomenclatural errors. We note that no scientific names (which are standardized according to internationally accepted rules) were indicated as incorrect.

COLORADO DEPARTMENT OF HEALTH

Richard D. Lamm
Governor

Thomas M. Vernon, M.D.
Executive Director

December 9, 1986

Mr. Donald Campbell
Environmental Engineering Division
Department of the Army
Program Manager, AMXRM
Aberdeen Proving Ground, Maryland 21010-5401

Dear Mr. Campbell:

Attached please find the specific comments generated by staff review of the Draft Final Phase II Biota Assessment Technical Plan. Several concerns of a general nature were raised and those are noted below:

- The list of constituents proposed for tissue analysis is extremely abbreviated. Substantial documentation is available, not only within the draft plan but from a number of other sources, pointing to the presence of a lengthy list of contaminants widespread in both the environment and biota at RMA. Implementation of the study as it is currently proposed would raise serious questions of consistency with section 300.68.k of the National Contingency Plan. The focus of the draft plan on organochlorines, arsenic and mercury, to the exclusion of a multitude of other toxicants, potentially invalidates the study.

- The adequacy of the proposed statistical treatment of data cannot be evaluated due to the fact that insufficient information is made available in the draft plan.

If you should have any questions regarding the enclosed comments please contact Mr. Phil Hegeman with the Water Quality Control Division.

Sincerely,

Richard J. Karlin

Richard J. Karlin, P.E.
Section Chief
Drinking Water/Ground Water Section

RJK/PH/caw

RESPONSES TO THE COLORADO DEPARTMENT OF HEALTH
COMMENTS ON THE
DRAFT FINAL PHASE II
BIOTA ASSESSMENT TECHNICAL PLAN
AUGUST 1986

General Comments in Cover Letter:

Comment 1: The list of constituents proposed for tissue analysis is extremely abbreviated. Substantial documentation is available, not only within the draft plan but from a number of other sources, pointing to the presence of a lengthy list of contaminants widespread in both the environment and biota at RMA. Implementation of the study as it is currently proposed would raise serious questions of consistency with section 300.68.k of the National Contingency Plan. The focus of the draft plan on organochlorines, arsenic and mercury, to the exclusion of a multitude of other toxicants, potentially invalidates the study.

Response: Additional chemicals have been reported from biota at RMA, but many of these have been eliminated from consideration on the basis of criteria provided in section 3.3 of Draft Final Technical Plan (e.g. known distribution on RMA is limited; low toxicity; and/or persistence data indicated that, if present, they would not be present in harmful concentrations). As indicated in the technical plan, the list of chemicals for analysis is subject to modification based on availability of new pertinent information. Given these considerations, the plan appears to be consistent with section 300.68 k of the National Contingency Plan.

Comment 2: The adequacy of the proposed statistical treatment of data cannot be evaluated due to the fact that insufficient information is made available in the draft plan.

Response: A detailed description of the statistical treatment of data was not intended as part of this technical plan. Decisions on the adequacy of the statistical treatment of data are more appropriately addressed as part of the review of reports resulting from investigations conducted under this plan.

Specific Comments

Comment 1:
p. 1-8 The distinction between the areas designated as "non-native herbaceous plants" and those designated as "crested wheat-grass" is an artificial one in light of the fact that crested wheatgrass is an introduced species.

Response: See text, p. 9.

Comment 2:
p. 1-12 The discussion of gamefish inhabiting portions of the arsenal should be amended to include northern pike.

Response: See text, p. 13.

Comment 3: p. 1-14 Meadow moles should read meadow voles.

Response: See text, p. 15.

Comment 4: p. 1-15 The discussion of organochlorines detected in the tissues of various biota collected on the arsenal may be subject to misinterpretation in that no mention is made of the limited number of toxicants subject to analysis. This deficiency should be noted.

Response: This discussion was provided as background for the studies planned in Phase II, not as a conclusion in a report.

Comment 5: p. 2-10 It is noted that recent surveys indicate usage of known or suspected contaminated groundwater for irrigation and livestock watering. Documentation in support of this statement should be included or referenced. Use of contaminated groundwater represents a serious route of exposure which is not addressed in the Biota Assessment. How is it being addressed?

Response: Documentation of known or suspected contaminated ground water sources for irrigation and livestock watering are contained in the Draft Final Offpost Contamination Assessment Report. Use of contaminated ground water could represent a serious route of exposure, and this route is being addressed for domesticated plants and animals in the technical plan (section 3.8). The potential for wildlife exposure in the offpost area will be addressed when data on contamination in surface and near surface areas becomes available. These exposure routes are also addressed for livestock, wildlife, and plants in the endangerment assessment currently being prepared for the offpost area.

Comment 6: p. 2-13,14 The inclusion of "volume" data as a criteria for establishing potential contaminants of concern is inappropriate. Many of the toxicants under consideration represent significant concerns regardless of the volumes involved. The volume categories selected are extremely subjective, due in part to the fact that the exact nature of disposed material (pure product, contaminated material, etc.) is undisclosed.

Response: The use of volume is subjective but not inappropriate. No chemical was eliminated from consideration on the basis of this single criterion.

Comment 7: p. 2-12 The discussion of source reports notes that fewer chemicals have been detected in the RMA environment than anticipated. Ten are cited as present in differing frequencies. This conclusion varies from that which is supported by the matrix (Table 2.2-1) which includes 36 chemicals under the heading "In RMA Environment".

Response: The source report data were obtained from current studies (1985-86). Data presented in Table 2.2-1 were taken from studies dating back as far as the 1950's. These chemicals could have dispersed or degraded to other compounds. These chemicals were "in the RMA environment".

Comment 8: Page 2-31 Insufficient data is presented in either the text or in Table 2.3-6 to support (with the exception of the fish kill which occurred on 5/16/73) any determination of cause of death.

Terminology such as "high levels" and significant concentrations: should be avoided unless accompanied by data which supports quantification of analyte concentrations.

Response: The column entitled "Apparent Cause of Death" presents conclusions reached in or as a result of the examination of the referenced document for each species. Supporting data are found in these documents and are not presented in this table.

Comment 9: p. 3-1 What is the rationale for assuming that restoration/ replacement will be used as a basis for damage determination in lieu of diminution of use values?

Response: Cost effectiveness and reasonable cost criteria are appropriate considerations in scoping Remedial Investigations in compliance with federal regulations and constitute a logical and responsible use of funds. These were not the sole criteria used in selecting methodologies.

Comment 10: p. 3-2 Soil types should be verified by field sampling. Soil survey maps may not provide the necessary degree of accuracy.

Response: SCS soil maps were used to identify areas similar in characteristics which might affect vegetation composition and distribution (i.e. slope, soil texture and composition, erodibility, capability unit, etc.). The SCS soil types appeared to be useful and appropriate.

Comment 11: Page 3-4 The significance of the contents of Table 3.1-1 is not readily apparent. A discussion of the table should be included in the text.

Response: See text, p. 3-3.

Comment 12: p. 3-5 The discussion of transect location randomness contradicts the statement on page 3-2 that transect location will be chosen based on soil texture, pH, etc.

Reference is also made on 3-5 to site characterization data including animal behavior and various physiological abnormalities of the vegetation. Aberrant behaviors and vegetative abnormalities may both be due to a number of causative factors. It does not appear that the procedures for identification and quantification of these traits has

been developed to the extent necessary to demonstrate any cause and effect relationships.

What is the rationale for selecting a 20 percent level of significance in lieu of 5 percent?

Response: See text for first comment, p. 3-5.

The documentation of aberrant behaviors would be used to identify potential areas and/or species for further investigation, not to demonstrate cause and effect relationships.

The phrase in the text is "above the 20 percent level". Phytotoxicity studies (RIC#81266R8) suggest that differences of 20 percent in growth are probably not significant, while differences of 100 percent in growth are probably very significant.

Comment 13: p. 3-6 Effects on populations of prairie dogs and pocket gophers occupying adjacent contaminated and uncontaminated areas can be demonstrated only if documentation is provided demonstrating no movement of individuals occurs between the populations.

Response: There are no sampling locations which include contiguous contaminated and uncontaminated areas. All such related sampling locations are separated by several miles.

Comment 14: p. 3-7 The discussion of toxicant effects on avifauna should not be limited to organochlorines.

Response: See text, pp. 3-7 and 3-8.

Comment 15: Page 3-12 Table 3.3-1 indicates the chemicals selected for for analysis will be limited to mercury, arsenic and the organochlorines. The list of analytes should be expanded to include, at a minimum, PCPMSO2, DBCP, DCPD, DIMP, DDE, and DDT, copper. All, according to TAble 2.2-1, have been documented as occurring in the RMA environment, have been found in biota sampled at RMA, and are moderately to severely toxic. Additionally, it is recommended that benzene, carbon tetrachloride, and chloroform be added. All have been utilized in large quantities, are extremely toxic and are persistent in the soil and groundwater. The lack of historical information documenting the presence of these constituents is probably because previous studies have consistently avoided looking for them.

It is noted that no piscifauna were included for tissue sampling, apparently due to the fact that representative species have been sampled earlier. Because earlier analysis was limited to organochlorines, arsenic and mercury, it is recommended that black bullhead and northern pike be added to the species list and samples obtained for more comprehensive list of analyses detailed previously.

Those tissue samples designated in Table 3.3-1 as "organ" should be discussed in the text to the extent that the target organ or organs are identified.

Response: The list of chemicals suggested for additional analysis (PCPMSO2, DBCP, DCPD, DIMP, DDE, DDT, and copper) is under consideration, pending review of data from studies on the distribution and concentration of these chemicals in soil, surface water and ground water at depths which present exposure pathways to the biota. Although these chemicals have been documented as present in biota sampled at RMA, several of these may not be hazardous to biota due to factors such as migration to deep ground water, chemical degradation, or because they are not currently known to be present in areas and/or concentrations which would pose substantial hazard to the biota. DDE and DDT are being added to the list of chemicals for analysis on the basis of additional data on their presence and potential importance on RMA.

We have reevaluated benzene, carbon tetrachloride, and chloroform and acknowledge their toxicity and persistence in the environment. We have examined the available literature and discussed the feasibility of analyzing biological tissues for these chemicals. Our information to date indicates that some would not be expected to occur in tissues because they are either metabolized to other compounds or exhaled, and, even if found, there is no data base relating levels of these compounds in biological materials to biological effects. While these chemicals may indeed produce adverse biological effects, tissue analysis does not appear to be the correct approach for evaluating them. We, therefore, disagree with the statement, "The lack of historical information documenting the presence of these constituents is probably because previous studies have consistently avoided looking for them."

Fish species were indeed eliminated from the proposed sampling program for the reasons indicated. Some fish sampling may be conducted at a later stage in the program, however Morrison-Knudsen Engineers, Inc. is currently conducting a sampling program which includes fish from the Lower lakes, and this program is presently designed to include an expanded list of chemicals.

The "organ" was not determined for all species pending the results of contamination assessment reports prepared for other environmental media and pending a thorough literature review of pertinent contaminants and possible/probable target organs for each. See text for changes.

Comment 16:
p. 3-18

No data is presented supporting the contention that the physical deformations referenced are due to organochlorine contamination alone?

Response: Such a discussion is appropriate for a report that presents the results of this study and was not believed necessary as part of the technical plan.

Comment 17: p. 3-29 Red-winged blackbirds are probably abundant enough to allow the sacrifice of sufficient individuals to document the presence or absence of internal skeletal or soft tissue abnormalities.

Response: We did not and do not believe that the level of effort and biological impact necessary to produce quantitative results are justified at this point.

STATE OF COLORADO
Richard D. Lamm, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
James B. Ruch, Director
6060 Broadway
Denver, Colorado 80216
Telephone: (303) 297-1192

January 22, 1987

Mr. Donald Campbell
Environmental Engineering Division
Department of the Army
Program Manager, AMXRM
Aberdeen Proving Ground, Maryland 21010-5401

Dear Mr. Campbell:

The Division of Wildlife has completed its review of the Draft Final Phase II Technical Plan and has the following comments.

There are several overall comments relevant to the entire document. First, we remain concerned by the continued reference to "reasonable cost" and "cost effectiveness" in judging the degree and appropriateness of biological assessment in this case. The damage regulations have still not been finalized. While they can provide guidance we do not believe they should be the basis for final determination of the scope of biota assessment.

While we appreciate the time and effort that has gone in to the preparation of this document, there remain, in our opinion, ommissions in the recommended procedures that could reduce the usefulness of the data collected in the proper assessment of damage. This is critical in making an accurate assessment of the cost of the damage to wildlife populations and the RMA ecosytem. We repeat the Colorado Department of Health's question: What is the rationale for assuming that restoration/replacement will be used as a basis for damage determination in lieu of diminution of use values?

Our specific comments are as follows:

1. Page 1-12 — The list of game fish in the Arsenal lakes should be amended to include Northern Pike.

2. Page 1-16 — This type of general discussion of contaminants found in wildlife tissues at the Arsenal would be more relevant if it contained the list of chemicals previously test for in those tissues.

3. Page 2-10 — Since wildlife also inhabits areas adjacent to RMA, there should be discussion of the potential impact of this ground water contamination to those species as well as to domestic biota.

4. Page 2-13,14 While the volume data may be useful in evaluating the degree to which a particular chemical was introduced in to the RMA environment, it has limited usefulness as a criteria for determining if it is a contaminant of concern. Many of these chemicals are a subject of concern regardless of the volume introduced.

5. Page 2-12 What is the reason for the difference in number of chemicals listed as detected in the RMA environment in this discussion and the list of 36 chemicals detected in the RMA environment shown in Table 2.2-1?

6. Page 2-31 There is insufficient information presented in this table to make a judgment about the apparent cause of death. The table would be more useful if footnotes explained the source of the cause of death information in addition to listing the actual reference. In addition, the definition of "significant concentration" and "high levels" should be footnoted on these tables.

7. Page 3-6 Important characteristics in assessing comparability to contaminated areas for the purpose of selecting control areas for wildlife should include potential for movement of control wildlife onto the Arsenal or other areas which may be contaminated; and the contamination history of any control area.

8. Page 3-5 The discussion of transect location randomness conflicts with the discussion of the choice of specific transect locations.This should be clarified to explain at what point speficity is needed and at what point randomness is needed.

9. Page 3-5 The usefulness of physiological abnormalities information in both plant and wildlife species is limited if the causative factor cannot be identified. What provisions are made to make these determinations. Also, what is the basis for choosing 20 % as the significant level of comparison for phytotoxic changes between plants from contaminated and control areas?

10. Page 3-7 The discussion of toxic effects on avifauna should not be limited to organochlorines if any judgment about the scope of relevant avifauna studies is to be drawn from this discussion. Also, there is no mention of the results of the Patuxent WRC's 2 year study of American kestrel reproduction. A short discussion of what measures were enacted to reduce exposure of birds to toxicants seems appropriate if this is believed to be have acted to reduce toxic chemical effects.

11. Page 3-11 The discussion of species and contaminants chosen for tissue analysis does not contain explanation of how sample size was determined nor the reasons why particular tissues were chosen. A short discussion of the type of information to be evaluated from the different tissue types would make

this chart much more useful. Organs should be listed and while it can be assumed that (WB) means whole body this is not footnoted. There is also no discussion of the source of testing protocol.

12. Page 3-12 At this point we repeat our concern that the list of chemicals chosen for study is insufficient. We concur with the Colorado Department of Health that the list should include PCPMSO2, DBCP, DCPD, DIMP, DDE, DDT, and Copper. All meet the criteria of occurring in the RMA environment, have been found in biota sampled at RMA, and are moderately to severely toxic. Further, we agree with CDOH that additional testing for benzene, carbon tetrachloride, and chloroform be added for the same reasons.

We do not agree with the Army's deletion of fish from the species to be sampled. Earlier analysis was for a much more limited list of chemicals.

Finally, there is no discussion of the similarities and differences between sampling and testing protocol used in earlier chemical analyses and that which will be used in these analyses.

In addition to the above listed comments on the actual documents, we would like to make the following recommendations:

The recent discovery of a communal Bald Eagle roost used by at least 20 Bald Eagles is, in our opinion, extremely significant in terms of biota and damage assessment. Furthermore, since the Bald Eagle is a State and Federally listed endangered species with limited wintering previously along the Front Range of Colorado, it seems judicious to take advantage of the opportunity to collect biological data. Monitoring by ESE since the discovery of the roost indicates that the Arsenal is also the primary feeding range for these birds. Therefore we urge the Army to expand the scope of this study to include casting analysis and food habit determination; roost monitoring, perch mapping, and if the occasion should arise, tissue sampling of any dead or dying eagles.

Another recurring subject of discussion has been the potential usefulness of deer collaring and/or radio telemetry to determine the extent of deer movement on and off the Arsenal. Deer are capable of moving large distances, and this has caused the Division to refrain from donating for human consumption any deer meat recovered in reasonable proximity to the Arsenal. Therefore, we feel this information would be a useful clarification and should be evaluated for inclusion in the biota assessment.

Thank You for the opportunity to comment.

Sincerely,

Katherine A. Demarest

Katherine A. Demarest
Terrestrial Wildlife Biologist
Central Region

cc: Lovell
Woodling
Platt

RESPONSES TO THE COLORADO DIVISION OF WILDLIFE
COMMENTS ON THE
DRAFT FINAL PHASE II
BIOTA ASSESSMENT TECHNICAL PLAN
AUGUST 1986

General Comments in Cover Letter

Comment 1: There are several overall comments relevant to the entire document. First, we remain concerned by the continued reference to "reasonable cost" and "cost effectiveness" in judging the degree and appropriateness of biological assessment in this case. The damage regulations have still not been finalized. While they can provide guidance we do not believe they should be the basis for final determination of the scope of biota assessment.

While we appreciate the time and effort that has gone in to the preparation of this document, there remain, in our opinion, omissions in the recommended procedures that could reduce the usefulness of the data collected in the proper assessment of damage. This is critical in making an accurate assessment of the cost of the damage to wildlife populations and the RMA ecosystem. We repeat the Colorado Department of Health's question: What is the rationale for assuming that restoration/replacement will be used as a basis for damage determination in lieu of diminution of use values?

Response: The restoration/replacement approach is consistent with the objectives of remedial investigation/feasibility studies under applicable regulations.

Comment 2: The recent discovery of a communal Bald Eagle roost used by at least 20 Bald Eagles is, in our opinion, extremely significant in terms of biota and damage assessment. Furthermore, since the Bald Eagle is a State and Federally listed endangered species with limited wintering previously along the Front Range of Colorado, it seems judicious to take advantage of the opportunity to collect biological data. Monitoring by ESE since the discovery of the roost indicates that the Arsenal is also the primary feeding range for these birds. Therefore we urge the Army to expand the scope of this study to include casting analysis and food habit determination; roost monitoring, perch mapping, and if the occasion should arise, tissue sampling of any dead or dying eagles.

Response: All of the suggestions made regarding investigations of bald eagles at RMA have been implemented as a result of the joint agency/contractor meeting held on January 8, 1987.

Comment 3: Another recurring subject of discussion has been the potential usefulness of deer collaring and/or radio telemetry to determine the extent of deer movement on and off the Arsenal. Deer are capable of moving large distances, and

this has caused the Division to refrain from donating for human consumption any deer meat recovered in reasonable proximity to the Arsenal. Therefore, we feel this information would be a useful clarification and should be evaluated for inclusion in the biota assessment.

Response: The Colorado Division of Wildlife, U. S. Army, and ESE, Inc. have reached an agreement in principle to conduct a cooperative effort to capture and track deer in order to determine their movements on and near the Rocky mountain Arsenal. Details are presently under discussion.

Specific Comments

Comment 1: Page 1-12 The list of game fish in the Arsenal lakes should be amended to include Northern Pike.

Response: See text, p. 13.

Comment 2: Page 1-16 This type of general discussion of contaminants found in wildlife tissues at the Arsenal would be relevant if it contained the list of chemicals previously test [SIC] for in those tissues.

Response: Many of the studies from which these data were taken were conducted for specific purposes. Such a discussion would be complex, but not necessarily appropriate for inclusion in a technical plan. The studies referenced are available for public review.

Comment 3: Page 2-10 Since wildlife also inhabits areas adjacent to RMA, there should be discussion of the potential impact of this ground water contamination to those species as well as to domestic biota.

Response: A potential for wildlife impacts which sufficiently demonstrate the need for investigation is presented on pages 2-10 and 2-11. A more extensive discussion of the potential/actual impact of ground water contamination on wildlife will be presented in the reports resulting from current investigations.

Comment 4: p. 2-13,14 While the volume data may be useful in evaluating the degree to which a particular chemical was introduced in to the RMA environment, it has limited usefulness as a criteria for determining if it is a contaminant of concern. Many of these chemicals are a subject of concern regardless of the volume introduced.

Response: Volume is used in combination with other criteria. It does provide some useful information in assessing potential adverse effects (i.e. spilling a 55 gallon drum of organic solvent is not equivalent to spilling a bottle of nail polish containing the same solvent).

Comment 5:
p. 2-12

What is the reason for the difference in number of chemicals listed as detected in the RMA environment in this discussion and the list of 36 chemicals detected in the RMA environment shown in Table 2.2-1?

Response:

The discussion of Table 2.2-1 was intended to provide background, and not to provide a detailed evaluation of each chemical. It is stated that all pertinent data on contaminant distribution in other environmental media were not available and understood, and that the list of contaminants of concern is flexible.

Comment 6:
p. 2-31

There is insufficient information presented in this table to make a judgement about the apparent cause of death. The table would be more useful if footnotes explained the source of the cause of death information in addition to listing the actual reference. In addition, the definition of "significant concentration" and "high levels" should be footnoted on these tables.

Response:

The column entitled "Apparent Cause of Death" presents conclusions reached in or as a result of the examination of the referenced document(s). See text for other changes.

Comment 7:
p. 3-6

Important characteristics in assessing comparability to contaminated areas for the purpose of selecting control areas for wildlife should include potential for movement of control wildlife onto the Arsenal or other areas which may be contaminated; and the contamination history of any control area.

Response:

Onpost control areas are sufficiently distant (more than a mile) from sites of similar contamination so that it is highly unlikely that small mammals and invertebrates sampled at these locations would have been exposed to contaminated areas. Offpost locations many miles distant from sites of know contamination were selected as a check on the onpost controls and for larger species with greater mobility and a greater potential to become exposed to sites of contamination. The report resulting from these studies will present maps indicating the location of all areas sampled.

Offpost study areas, including Pawnee Grasslands, Wellington Wildlife Area, property south of the Rawhide Power Plant, and CSU property in Fort Collins have no history of chemical contamination. Rangers, property owners, and local researchers were queried regarding the contamination history of their areas, and no suspicious events were discovered.

Comment 8:
p. 3-5

The discussion of transect location randomness conflicts with the discussion of the choice of specific transect locations. This should be clarified to explain at what point specificity is needed and at what point randomness is needed.

Response:

See text, pp. 3-5.

Comment 9: p.3-5

The usefulness of physiological abnormalities information in both plant and wildlife species is limited if the causative factor cannot be identified. What provisions are made to make these determinations. Also, what is the basis for choosing 20 % as the significant level of comparisons for phytotoxic changes between plants from contaminated and control areas?

Response:

In this instance, physiological abnormalities would be used to determine areas of additional investigation (e.g. more chemical analysis of tissues and/or documentation of effects), and not as a definitive indication of the effect of particular chemicals.

The phrase used is "above the 20% level." Phytotoxicity studies (RIC #81266 R8) suggest that differences of 20% in growth are probably not significant, while differences of 100% in growth are probably very significant.

Comment 10: p. 3-7

The discussion of toxic effects of avifauna should not be limited to organochlorines if any judgement about the scope of relevant avifauna studies is to be drawn from this discussion. Also, there is not mention of the results of the Patuxent WRC's 2 year study of American kestrel reproduction. A short discussion of what measures were enacted to reduce exposure of birds to toxicants seems appropriate if this is believed to have acted to reduce toxic chemical effects.

Response:

The results of the Patuxent WRC's investigation of American kestrel reproduction study were not available at the time that this technical plan was assembled. Verbal indications from U. S. Fish and Wildlife Service investigators involved in the kestrel study indicated that the reproductive success study, as scoped, would be appropriate.

Comment 11: p. 3-11

The discussion of species and contaminants chosen for tissue analysis does not contain explanation of how sample size was determined nor the reasons why particular tissues were chosen. A short discussion of the type of information to be evaluated from the different tissue types would make this chart much more useful. Organs should be listed and while it can be assumed that (WB) means whole body this is not footnoted. There is also no discussion of the source of testing protocol.

Response:

See text of Letter Technical Plan.

Comment 12: p. 3-12

At this point we repeat our concern that the list of chemicals chosen for study is insufficient. We concur with the Colorado Department of Health that the list should include PCPMSO2, DBCP, DCPD, DIMP, DDE, DDT, and Copper. All meet the criteria of occurring in the RMA environment, have been found in biota sampled at RMA, and are moderately to severely toxic. Further, we agree with CDOH that additional

testing for benzene, carbon tetrachloride, and chloroform be added for the same reasons.

We do not agree with the Army's deletion of fish from the species to be sampled. Earlier analysis was for a much more limited list of chemicals.

Finally, there is no discussion of the similarities and differences between sampling and testing protocol used in earlier chemical analyses and that which will be used in these analyses.

Response: See response to similar comment by Shell Oil Company, response to comment on Page 3-12.

Recent reports of contaminants present in sediment and water and related pathways information do not indicate a need for the analysis of additional chemicals in fish tissues. The plan currently proposed by Morrison-Knudsen Engineers, Inc. may provide some current information on an expanded list of chemicals.

A discussion comparing current and past testing protocols is not necessary for evaluation of this technical plan.

United States Department of the Interior
FISH AND WILDLIFE SERVICE

MAILING ADDRESS:
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
134 Union Blvd.
Lakewood, Colorado 80228

IN REPLY REFER TO:

FWE/ES
MAIL STOP 60120

FEB 03 1987

Dr. Douglas P. Reagan
Environmental Science
and Engineering
Suite H
7332 South Alton Way
Englewood, Colorado 80112

Dear Dr. Reagan:

In response to your request for members of the Rocky Mountain Arsenal Biota Assessment MOA Subcommittee to review and comment on the "Draft Final Phase II Technical Plan, Rocky Mountain Arsenal Biota Assessment," the following comments are submitted.

The subject document does a good job in laying out the rationale and basis for the proposed course of action. The main weakness is the lack of provisions for meeting the need for collecting new unforeseen data such as will be necessary for the winter Bald Eagle roost. The technical plan should be up front about providing for such contingencies.

Specific comments follow:

Page 1-3, paragraph 2. "Basin A, located within Section 36," is mentioned in this paragraph. It would be helpful to have a map showing the Sections and locations of lakes, basins, structures, etc., which are mentioned in Chapter 1. This addition would help the readers to orient themselves.

Page 1-19, paragraph 1.4.4, STUDY COORDINATION. The U.S. Fish and Wildlife Service is not one of the parties to the Memorandum of Agreement mentioned in this section.

Page 2-4, last paragraph, line 2. Delete "on"; insert "of."

Page 2-6, last line. Delete "have."

Page 2-9. Locate basins C, D, E, F, North Bay on Figure 2.1-3.

Page 2-12, last paragraph, sentence 2. Insert "which" between "study" and "involved."

Page 3-2, line 21. "This" should be "These."

Page 3-3, line 9. Change "man" to "may."

Page 3-3, Vegetation. Soil Conservation Service maps were overlayed on vegetation maps to determine areas where major soil and vegetation types occurred in relation to contamination. This approach may not be valid in the areas where sediments were dredged out of the lakes and stockpiled, then covered with topsoil. These sites may not agree with the SCS maps.

Page 3-5, lines 27 and 28. Delete "changes"; insert "differences."

Page 3-6, line 13. Change "effects" to "differences."

Page 3-6, line 19. Did the Colorado Division of Wildlife conduct Federal Aid studies on the Arsenal or is this a reference to the studies conducted by Rosenlund, U.S. Fish and Wildlife Service? If the reference is to Rosenlund, then "Aid" should be changed to "Assistance."

Page 3-6, line 26, "PH" should be "pH."

Page 3-7, second full paragraph. These questions should be changed to goals.

Page 3-8, line 3. Change "weather" to "whether."

Page 3-10, line 2, "section" should be "sections."

Page 3-10, line 2. Is this schedule still valid?

Page 3-10, last paragraph. Give the citation for the "regulatory requirements."

Page 3-11, line 12, "assessment" should be "Assessment."

Page 3-11, last line. Insert "not" between "is" and "readily."

Page 3-11, last paragraph; and page 3-13, first paragraph. Does this mean that if ChE inhibition is detected, then one knows that organophosphorus and/or carbonate pesticides were possible causes of death, instead of some other toxicant?

Page 3-13, last 2 lines, "use of least." What does this mean?

Page 3-14, first paragraph on criteria for species list. Need a better description of criteria used.

Page 3-14, line 15, key ___?___ species? Some descriptive word is needed.

Page 3-15, last paragraph, line 8. Add "toxic" after "containing."

Page 3-19, sentence 1, "criteria" cite reference for "criteria."

Page 4-1, line 4, "bioilogical" should be "biological."

Page 4-1. Move paragraph 3 from "Certification" to paragraph 2, "Sample Analysis."

Page 5-1, line 1. Insert "Plan" between "(QA)" and "for."

Page 5-1, line 2. Beginning of sentence 2, change to read, "The Task 9 Plan."

Page 6-1, paragraph 2, last sentence. Need explanation of "Level 2."

Sincerely,

Dale A. Hoffman

Dale A. Hoffman
Staff Biologist

cc: Kevin Blose
Office of Program Manager
RMA Contamination Cleanup
Attn: AMXRM-EE
Building E 4585
Aberdeen Proving Ground,
Maryland 21010-5401

RESPONSES TO THE U.S. FISH AND WILDLIFE SERVICE COMMENTS ON THE DRAFT FINAL PHASE II BIOTA ASSESSMENT TECHNICAL PLAN AUGUST 1986

General Comments in Cover Letter

Comment 1: The subject document does a good job in laying out the rationale and basis for the proposed course of action. The main weakness is the lack of provisions for meeting the need for collecting new unforeseen data such as will be necessary for the winter Bald Eagle roost. The technical plan should be up front about providing for such contingencies.

Response: Provision has been made for contingency work such as the bald eagle survey work, in fact investigation of bald eagles proceeded without delay from the time of roost discovery. Apart from stating that the technical plan is flexible, it was not felt necessary to elaborate on this possibility.

Specific Comments

Comment 1: p. 1-3, para. 2 — "Basin A, located within Section 36," is mentioned in this paragraph. It would be helpful to have a map showing the Sections and locations of lakes, basins, structures, etc., which are mentioned in Chapter 1. This addition would help the readers to orient themselves.

Response: See Figure 1.1-2

Comment 2: p. 2-4, para.1.4.4, STUDY COORDINATION — The U.S. Fish and Wildlife Service is not one of the parties to the Memorandum of Agreement mentioned in this section.

Response: See text for correction.

Comment 3: p. 2-4, last para., line 2 — Delete "on"; insert "of".

Response: See text, p. 2-4.

Comment 4: p. 2-6, last line — Delete "have."

Response: See text, p. 2-6.

Comment 5: p. 2-9 — Locate basins C, D, E, F, North Bay on Figure 2.1-3

Response: See Figure 1.1-2

Comment 6: p. 2-12, last para. — Insert "which" between "study" and "involved".

Response: See text, p. 2-12.

Comment 7: p. 3-2, line 21 — "This" should be "These."

Response: See text,p. 3-2.

Comment 8: Change "man" to "may."

Response: See text, p. 3-2.

Comment 9: p. 3-3, Vegetation — Soil Conservation Service maps were overlayed on vegetation maps to determine areas where major soil and vegetation types occurred in relation to contamination. This approach may not be valid in the areas where sediments were dredged out of the lakes and stockpiled, then covered with topsoil. These sites may not agree with the SCS maps.

Response: See text.

Comment 10: p. 3-5, lines 27 and 28 — Delete "changes"; insert "differences."

Response: See text, p. 3-5.

Comment 11: p. 3-6, line 13 — Change "effects" to "differences."

Response: See text, p. 3-6.

Comment 12: p. 3-6, line 19 — Did the Colorado Division of Wildlife conduct Federal Aid studies on the Arsenal or is this a reference to the studies conducted by Rosenlund, U.S. Fish and Wildlife Service? If the reference is Rosenlund, then "Aid" should be changed to "Assistance."

Response: Refers to CDOW studies.

Comment 13: p. 3-6, line 26 — "PH" should be "pH."

Response: See text, p. 3-18.

Comment 14: p. 3-7, 2nd full para. — These questions should be changed to goals.

Response: Comment noted.

Comment 15: p. 3-8, line 3	Change "weather" to "whether."
Response:	See text, p. 3-8.
Comment 16: p. 3-10, line 2	"section" should be "sections."
Response:	See text, p. 3-10.
Comment 17: p. 3-10, line 2	Is this schedule still valid?
Response:	This schedule has been modified.
Comment 18: p. 3-10, last para.	Give the citation for the "regulatory requirements."
Response:	See text, p. 3-10.
Comment 19: p. 3-11, line 12	"assessment" should be "Assessment."
Response:	See text, p. 3-11.
Comment 20: p. 3-11, last line	Insert "not" between "is" and "readily."
Response:	See text, p. 3-11.
Comment 21: p. 3-11, last para; and p. 3-13, 1st para.	Does this mean that if ChE inhibition is detected, then one knows that organophosphorus and/or carbonate pesticides were possible causes of death, instead of some other toxicant?
Response:	If acetylcholinesterase inhibition is detected, additional chemical tests may be performed on brain tissues in order to determine which chemicals may be involved.
Comment 22: p. 3-13, last 2 lines	"use of least." What does this mean?
Response:	See text for change.

Comment 23: p. 3-14, 1st para on criteria for species list — Need a better description of criteria used.

Response: See text, p. 3-14.

Comment 24: p. 3-14, line 15, key _____ species? — Some descriptive word is needed.

Response: Key species are defined on page 2-10 of November 1985 (Phase I) Draft Final Technical Plan.

Comment 25: p. 3-15, last para., line 8 — Add "toxic" after "containing."

Response: See text, p. 3-15.

Comment 26: p. 3-19, sentence 1 — "criteria" cite reference for "criteria."

Response: See text, p. 3-19.

Comment 27: p. 4-1, line 4 — "bioilogical" should be "biological."

Response: Typo corrected.

Comment 28: p. 4-1 — Move paragraph from "Certification" to paragraph 2, "Sample Analysis."

Response: We believe that this paragraph is located appropriately

Comment 29: p. 5-1, line 1 — Insert "Plan" between "(QA)" and "for."

Response: See text, p. 5-1.

Comment 30: p. 5-1, line 2 — Beginning of sentence 2, change to read, "The Task 9 Plan."

Response: See text for change.

Comment 31: p. 6-1, para 2, last sentence — Need explanation of "Level 2."

Response: See Task 1 Technical Plan for explanation.

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Letter Technical Plan
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

APPENDIX C
TASK 9 LETTER TECHNICAL PLAN, JULY 1988
AND COMMENTS AND RESPONSES TO THE
TASK 9 LETTER TECHNICAL PLAN

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

Letter Technical Plan
July 1988

Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

SAMPLING PROGRAM MODIFICATIONS

1.0 BALD EAGLE AND RAPTOR STUDIES

On 12 December 1986, a winter roost of bald eagles was discovered in a stand of mature cottonwood trees along First Creek on Rocky Mountain Arsenal (RMA). Observations were immediately initiated, and a bald eagle study plan was developed and discussed at a meeting on 8 January 1987 of all interested parties including the Colorado Division of Wildlife (CDOW), U.S. Fish and Wildlife Service (USFWS), Shell, Morrison-Knudsen Engineers, Inc. (MKE), U.S. Army Project Managers Office for RMA Contamination Cleanup, and Environmental Science and Engineering, Inc. (ESE).

The following methods were developed in order to gather pertinent data on the bald eagles and other important raptor species (e.g., ferruginous hawks) at RMA which are involved in the feeding activities of the eagles, and/or which are important in their own right as candidate species for possible listing for Threatened or Endangered status by the USFWS.

1.1 U.S. FISH AND WILDLIFE INVESTIGATION SUPPORT

In accordance with the cooperative agreements between the USFWS and the Army, ESE will assist the USFWS during the 1986-1987 and 1987-1988 winter seasons with radiotelemetry, prey base studies, and eagle capture as described in the proposals entitled: "The Potential Effects of Rocky Mountain Arsenal Cleanup Activities and Denver Metropolitan Transportation Devlopment on Bald Eagles" and "Lead Contamination in Migrant and Wintering Populations of Bald and Golden Eagles in Colorado And Utah" developed by the USFWS.

1.2 MIDDAY RAPTOR CENSUSES

Midday censuses for bald eagles, golden eagles, and other raptors will be conducted on a biweekly basis from mid-November through March 1988, or until all bald eagles have left RMA. These surveys will be conducted primarily to gain information on daily activity, habitat use, and feeding behavior of bald eagles in relation to habitat, prey, and other raptors on RMA.

All road count methods have inherent biases (weather, season, time of day) for which biologists must compensate (Fuller and Mosher, 1981). Kochert (1986) suggests alternating the direction of each survey run, restricting runs to specific times of day, and replicating runs in order to increase accuracy. Transect directions on RMA will be periodically alternated between north-south and east-west directions in order to reduce potential biases, to maximize raptor visibility (i.e., avoid looking directly into the sun), to avoid altering normal raptor behavior, and as road conditions dictate.

Observers trained in eagle identification will be stationed at 1 mile intervals along section roads. Each team member will carry a two-way radio, watch, and binoculars. In addition, spotting scopes will be used at some locations. The survey will be coordinated by a team leader using the two-way radios. On receiving instructions to proceed, each team member will drive slowly to the next section road, stopping as necessary to age and identify raptors. All intersecting section roads will be crossed simultaneously, and radio communication will be maintained between observers to eliminate double counting of eagles which might be visible to more than one observer. Transects are surveyed twice each sampling date; once in either direction (e.g., east to west in morning and west to east in the early afternoon). The following data will be recorded:

- Species,
- Age class of bald eagles and golden eagles (if discernable),
- Location (by quarter section or specific perch),
- General activity (flying, perching, feeding), and
- Date and time of observation.

To increase accuracy, the midday census will be conducted in conjunction with simultaneous radio tracking studies, whenever possible, during the 1987-1988 season.

To compare the numbers of bald eagles active on RMA during the day to nocturnal counts, a roost survey will be conducted on the evening or morning preceding the midday census, and/or evening on the date of each census.

1.3 ROOST COUNTS

The roost area is located in a gallery forest of mature plains cottonwood trees interspersed with younger-aged cottonwoods. The trees form a contiguous stand 520-meters (m) long and 30- to 60-m wide along First Creek. This gallery is surrounded by open grassland which provides excellent visibility for roosting bald eagles. The eagles roost in the largest cottonwoods in the stand, which are characterized by open canopies and numerous large horizontal branches for perching.

To determine environmental factors that may attract bald eagles to the roost on RMA, weather variables (wind, temperature, precipitation,) may be measured in a cottonwood stand similar to the roost and compared to data collected simultaneously in open grasslands during the 1987-1988 winter season.

A roost count will be conducted on a regular basis (weekly during the 1986-1987 season, and at approximately 5-day intervals during the 1987-1988 season) by trained observers. Each count will begin at dawn and/or dusk. Dawn counts will begin 1/2 hour before sunrise and continue 1/2 hour past sunrise. Dusk counts will begin 1 hour before sunset and continue until dark. Observers will use binoculars and spotting scopes from observation points at least 1/3 mile from the roost area. Work done by Stalmaster and Newman (1978) and Platt (1976) suggested that bald eagles adapt to slight disturbances that occur on a routine basis. For this reason, the same vehicles will be used for roost counts, to the extent possible. Two observers using two-way radios, one each on the west and east side of the roost, provide the most accurate count. This technique will be employed as often as is feasible.

Data collected during roost counts included:

- The number and age class of the eagles occupying the roost using the plumage classes described by Southern (1967) for bald eagles and standard adult/subadult plumage categories for golden eagles,
- The time and direction that eagles fly into and away from the roost,
- General weather conditions,

- o Perch selection characteristics and tree locations in the roost area, and
- o General behavior (e.g., vocalization, following and interactive behavior between age classes).

Analyses of these data will be coordinated with radiotelemetry data for birds equipped with radiotransmitters.

1.4 CASTINGS ANALYSIS

Raptor pellets (castings) can provide information on prey species utilized by bald eagles (Steenhof, 1978). In an effort to collect information on prey species for evaluation of contaminant pathways, whole pellets will be collected from directly beneath the RMA roost (when the roost area is totally unoccupied), then again after all bald eagles depart in the spring. To eliminate the possibility of misidentifying specimens, castings will be compared to reference collections obtained from captive raptors provided by Ms. Sigrid Ueblacker (Birds of Prey Rehabilitation Foundation). Questionable samples will be taken to Mr. Jerry Craig (Colorado Division of Wildlife) for positive identification. Pellets will then be analyzed following guidelines established by Polonsky (unpublished). Each pellet will be dried at 80 degrees Celsius (^{o}C), photographed, weighed, and measured. Identifiable material such as guard hairs, teeth, claws, bones, scales, and feathers will be separated from pellets under a dissecting microscope and used for food source identification. These materials will be compared to reference specimens collected on RMA, and guard hairs will be identified according to the methodology of Moore et al. (1974). Feathers will be separated, and submitted to experts of the USFWS for identification when possible. Following the methodology described by Polonsky (unpublished), castings will also be thoroughly checked for evidence of lead shot.

1.5 FEEDING OBSERVATIONS

Castings analysis of raptors such as eagles does not provide complete information on food habits. Bones are largely digested, castings may be scattered throughout the habitat, and medium to large individual prey may be represented in more than one casting (Errington, 1930), making determination

of the actual number of prey items consumed difficult. Methods currently being developed that combine casting analysis with collection of prey remains and actual feeding observations to give a more complete and accurate analysis of raptor food habits (Mersmann et al., 1987).

Feeding observations will be conducted to augment data obtained from casting studies and to determine the location and method of prey capture. Observations will be made systematically and, to the extent possible, in conjunction with radiotelemetry studies. Data collected will include:

- Age and species of eagle,
- Location, date, and time of observation,
- General weather conditions,
- Specific feeding perches (ground, tree, pole),
- Prey species,
- Method of procurement (e.g., original kill, kleptoparasitism, carrion feeding)
- Number of eagles feeding or watching,
- Other scavenging or predatory vertebrates in the vicinity, and
- Number of pirating attempts/successes (ground or aerial) and the age and species being pirated.

Whenever possible, prey remains will be collected from known bald eagle predation to determine prey species and portion consumed.

1.6 CONTAMINANT ANALYSES

As winter progresses and forage plants become scarce, prey species are forced to feed on available food, which often includes less desirable species and plants of poor nutritional value. This shift in dietary habits may affect the mobilization and amount of contaminants accumulated by prey species, and hence the predators that feed upon those species. Therefore, ESE may collect specimens (not more than 45 total) of important bald eagle prey items for contaminant analysis. Five prairie dogs will be collected from each of the following locations: Section 36, toxic storage yard, and from onpost control areas in Sections 19 and 20. Lagomorphs (rabbits and hares), which are also consumed by eagles on RMA, will be collected from

areas of potential contamination (e.g., Section 36) and from control areas offpost.

1.7 RAPTOR NEST SURVEYS

Raptor nest surveys were requested by the USFWS because of the abundance of raptors observed on RMA in the course of other studies. The results of nest surveys provide pertinent information on the relation of this important animal group in relation to RMA sites of contamination, and provides additional information relevant to the development and evaluation of remiation plans for the RMA.

Raptor nest surveys are based the techniques described by Call (1978), and from recommendations made by Mike Lockhart, USFWS raptor expert working on RMA (personal communication to ESE). Surveys emphasize endangered and threatened raptors and candidate species for federal listing (e.g., bald eagle, golden eagle, ferruginous hawk, and Swainson's hawk) and falcons, all of which have been observed on RMA. The nests of other raptor species (e.g., owls) are also recorded as encountered.

Initial surveys are conducted in early May, before the foliage of deciduous trees can obstruct observations. Surveys are conducted on foot in all wooded areas. All potential and active raptor nests are described on data sheets and mapped. Particular attention is paid to nests fitting the nest characteristics of early nesting species.

A second survey is conducted in June to include any active nests of late-nesting species, and to verify potentially active nests located during the initial survey. All wooded areas on RMA are again searched for new nests and to recheck nests located during the initial survey. A nest is considered active if:

- An adult is observed on the nest incubating eggs,
- Young are observed in the nest,
- An adult pair is observed defending the nest,
- An adult pair is observed in close association with a nest that shows recent evidence of construction or repair, or
- Incubation exchanges are observed.

Special precautions are taken not to disturb nesting birds. Observations are made from a distance using binoculars and spotting telescopes. Surveys are not conducted during periods of cold weather in order to avoid the possibility of accidentally flushing incubating birds and exposing eggs to adverse weather conditions.

2.0 PRAIRIE DOG STUDIES

Black-tailed prairie dogs will be investigated to determine their distribution and abundance on RMA. Information on the distribution of prairie dogs on RMA is needed in order to evaluate eagle and other raptor foraging habitat and to define areas of potential black-footed ferret habitat. An investigation of prairie dog populations on RMA is necessary in order to supplement bald eagle studies by evaluating the prairie dog prey base. These studies were planned in response to data needs indicated by the USFWS.

The counting technique used to estimate prairie dog populations is based on techniques developed and used by Fagerstone (1984) on Richarson's ground squirrels, and Fagerstone and Biggins (1986) on white-tailed prairie dogs. Both species are similar to black-tailed prairie dogs in their strictly diurnal activity and their colonial habits.

A map of prairie dog colonies is generated by examination of recent black and white aerial photographs (scale of 1 in = 600 ft). Prairie dog colonies are outlined on a transparent mylar sheet. This mapped information is verified and updated by groundtruthing visits throughout the RMA.

For the summer survey, twenty 1-hectare plots (100 m x 100 m) will be determined by random selection of coordinates of a grid superimposed on the prairie dog colony map, applying the following restrictions:

1. Plots must fall within an active prairie dog colony,
2. Plots do not duplicate a previously chosen location, and
3. Plots will not fall within sites of known contamination.

For the winter survey, conducted in conjunction with USFWS eagle studies, 12 plots will be selected according to criteria 1 and 2, but with the constraint that 4 plots will be located in each of the large prairie dog towns used by eagles, and that 2 of the plots in the central town will fall within Section 36. Plots 1 through 20 will be surveyed during the summer of 1987. Plots 2, 3, 12, and 20 (in west town); plots 5, 6, 10, and 15 (in east town); and plots 21, 22, 23, and 24 (in middle town) will be surveyed during the winter of 1987-1988. Figure 2.0-1 shows the location of prairie dog towns and survey plots. All plots are flagged with 1-m stakes at each corner and smaller (40-cm high) flags at intervals along each side.

Previous studies (King, 1955; Fagerstone and Biggins, 1986) indicate that the morning activity period yields the highest visual count of prairie dogs. Prairie dogs are then counted on each plot for three consecutive mornings for at least 75 minutes, usually between 0700 and 1030 hours during the summer. Upon arrival at the plot, the observer occupies a location from which he/she can see the entire plot and waits for at least 15 minutes before the first count. Counting then begins with the aid of binoculars and proceeds from one side of the plot to the other without backtracking for a maximum of 5 minutes. The observer then waits a minimum of 15 minutes before taking the next count. The maximum number of individuals in any single count over the 3-day (12 counts) observation period at each site is then used as the minimum population estimate for that plot.

3.0 BLACK-FOOTED FERRET SURVEY

Black-footed ferret surveys are planned as a result of direction provided by the USFWS, and follow the "Black-footed Ferret Survey Guidelines for Compliance with the Endangered Species Act" published by the USFWS in March 1986. Data on current prairie dog distribution on RMA is used to determine the location and amount of area to be surveyed. Nocturnal surveys are then conducted between July 1 and October 31.

Areas to be surveyed are divided into tracts of approximately 300 acres. A team of two people is responsible for surveying one tract over a 3-night period. Abbreviated daytime surveys of each tract are also conducted to

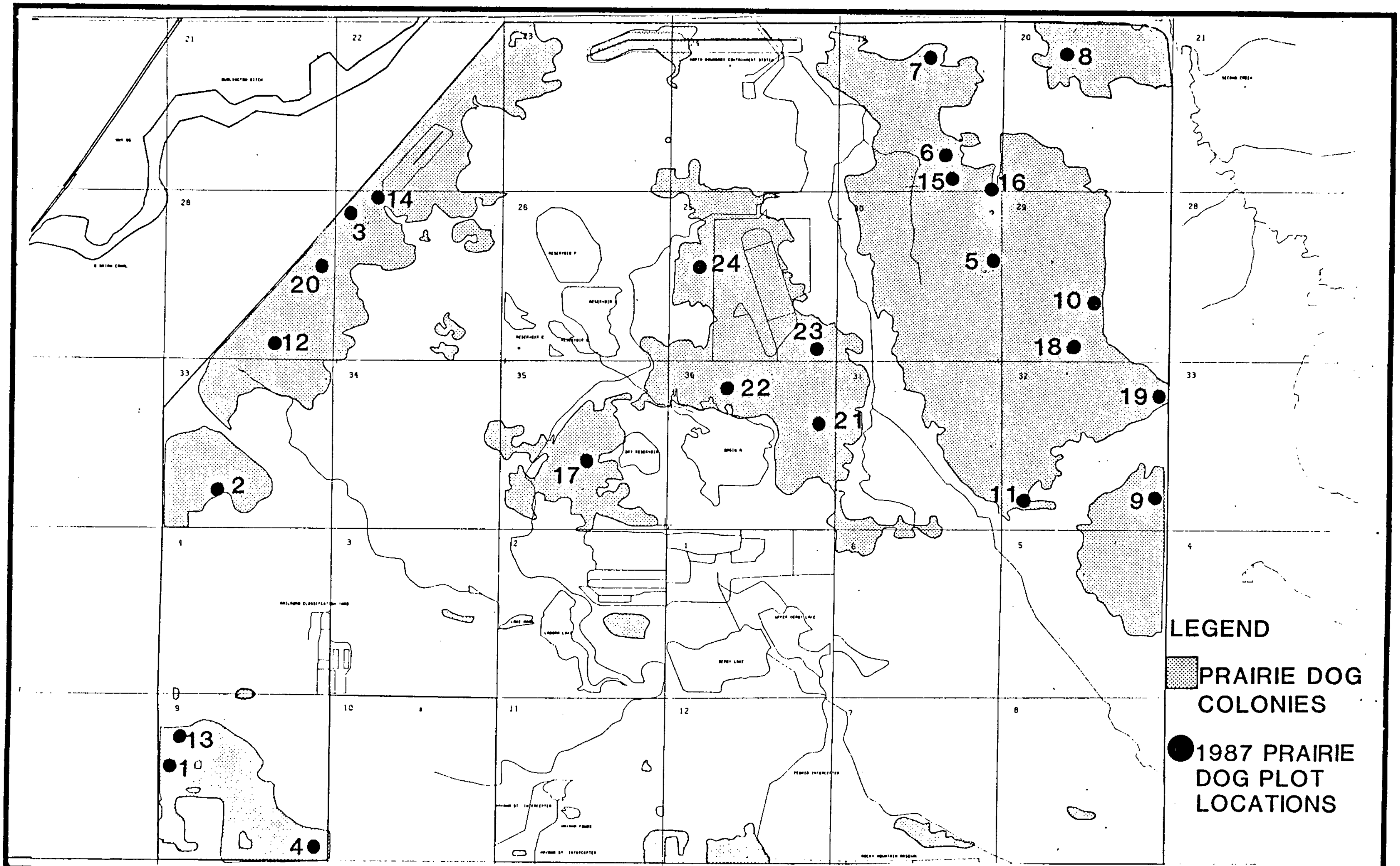


Figure 2.0–1
ROCKY MOUNTAIN ARSENAL
PRAIRIE DOG COLONIES

SOURCE: ESE, 1987

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

flag transects and obstacles, and to look for ferret sign prior to commencement of nighttime surveys of each tract.

Each tract is surveyed during three shifts per night: shift 1 begins at dusk (2000 to 2100 hours), shift 2 begins between 0000 and 0100 hours, and shift 3 begins around 0230 hours. Each survey team consists of two people, at least one of which has completed the USFWS Black-footed Ferret Certification Course. Each team is equipped with at least two 200,000-candle power lamps which are operated from the vehicles. Sealed batteries are carried as back-up power sources and to provide additional mobility from vehicles.

4.0 INVERTEBRATE POPULATION STUDIES

Additional invertebrate population studies will be conducted in order to provide better seasonal data on the abundance of these groups, and to obtain additional information which could not be collected during earlier surveys. The collection method remains as stated in the existing Biota Assessment Phase II Draft Final Technical Plan (ESE, 1986, RIC#86251R01).

5.0 ANALYSIS OF TISSUE SAMPLES

Since the release of the Phase II Draft Final Technical Plan, several additional samples have become available for analysis. These include animals collected outside of the prescribed collecting program, but which can provide additional pertinent information on contamination distribution in biota and contaminant effects.

Animal specimens from RMA which meet one or more of the following criteria are collected:

- Died of undetermined causes (e.g., not road kills),
- Exhibited outward signs of potential toxic effects, and
- Represent higher trophic levels or species other than those specified in the analysis program (Table 5.0-1).

These specimens are referred to as samples of chance. All or selected parts of these organisms are saved, pending reevaluation to determine what samples should be analyzed in discussions with the USWFS. It is currently anticipated that approximately 50 to 80 samples will be analyzed for

Table 5.0-1. Species and Contaminants for Tissue Analysis (page 1 of 2)

Species/Group	Locations+	Estimated Number of Samples Analyzed for: As	Hg	OCPs*	DDE/DDT	Tissues
Black-tailed Prairie Dog	RMA, Sec. 36 (sum)	8	8	8		carcass
	Control (on, sum)	8	8	8		"
	Control (off, sum)	8	8	8		"
	RMA, Sec. 36 (win)	5	5	5		"
	Tox. Yard (win)	5	5	5		"
	Control (on, win)	5	5	5		"
Desert Cottontail	RMA, Sec. 36	8	8	8		muscle
	Control (on)	8	8	8		"
	Control (off)	8	8	8		"
Mule Deer	RMA	9	9	9		muscle
	Control (off)	3	3	3		"
	RMA	9	9	9		liver
	Control (off)	3	3	3		"
Mallard	RMA		8	8	8	egg
	RMA		8	8	8	fledgling
	RMA		8	8	8	ad. carcass
	Control (off)		8	8	8	egg
	Control (off)		8	8	8	fledgling
	Control (off)		8	8	8	ad. carcass
Ring-necked Pheasant	RMA	8	8	8	8	egg
	RMA	8	8	8	8	juv. carcass
	RMA	8	8	8	8	ad. carcass
	Control (off)	8	8	8	8	egg
	Control (off)	8	8	8	8	juv. carcass
	Control (off)	8	8	8	8	ad. carcass
American Kestrel	RMA		10	10	10	egg
	RMA		10	10	10	fledgling
	Control (off)		10	10	10	egg
	Control (off)		10	10	10	fledgling
Earthworms	RMA, South Plants	3	3	3	3	composite
	RMA, control	3	3	3	3	"

Table 5.0-1 Species and Contaminants for Tissue Analysis (continued, Page 2 of 2)

Species/group	Locations+	Estimated Number of Samples Analyzed for As	Hg	OCPs*	DDE/DDT	Tissues
Grasshoppers	RMA, Sec. 36	3	3	3	3	composite
	RMA, Sec. 26	3	3	3	3	"
	RMA, control	3	3	3	3	"
	Control (off)	3	3	3	3	"
Aquatic Macrophytes	RMA Lakes		5	5		whole plant
	Control (off)		5	5		" "
Common Sunflower	RMA, Secs. 26 & 36	8	8	8	8	leaves, flowers
	Control (on)	2	2	2	2	" "
Morning Glory	RMA, Sec. 36	4	4	4	4	whole plant
	Control (on)	2	2	2	2	" "
Samples of Chance	RMA & offpost	50	80	80	50	liver and brain
USFWS samples	RMA & offpost	40	40	40	40	see text, Section 5.1

* OCP = the organochlorine pesticides (aldrin, dieldrin, and endrin).

\+ Sum = Summer
Win = Winter
On = Onpost
Off = Offpost

organochlorine pesticides (aldrin, dieldrin, endrin) and heavy metals (arsenic and mercury) (see Table 5.0-1). Additional kestrel egg samples from nests that failed are included in this category.

Brain samples from a variety of animals collected on RMA and from offpost control areas may also require analysis. Decisions on the number of samples to be analyzed and type of analyses have not been made, pending the outcome of acetylcholinesterase inhibition tests and the results of biota pathways analysis. It is anticipated that 20 to 30 samples will be analyzed for organochlorine pesticides (aldrin, dieldrin, endrin) and heavy metals (arsenic and mercury).

In addition to aforementioned samples, specimens collected by the USFWS and samples from terrestrial plants on RMA have also been added to the list of specimens for contaminant analysis. These additions have come about as the result of discussions with the USFWS and ongoing pathways analysis for contaminants of concern on RMA. Table 5.0-1 is a revision of Table 3.3-1 from the Phase II Draft Final Technical Plan and will be included in the Final Technical Plan, pending incorporation of additional review comments.

5.1 U.S. FISH AND WILDLIFE SERVICE SPECIMENS

The U.S. Fish and Wildlife Service has collected tissue samples from portions of RMA since 1982 for the purpose of contaminant analysis. These specimens are in the custody of the USFWS, but are not currently scheduled for analysis by USFWS. Several of these samples are of species and from areas of RMA which could produce valuable information on the distribution of contaminants in onpost biota. These samples have been prioritzed with respect to the complementarity with current biota sampling and with the potential relevance of the data to the biota assessment in consultations between the USFWS and the Army. Samples selected for chemical analysis include:

- Nine American coot (breast meat and liver),
- Three blue-winged teal (breast meat and liver),
- Five redhead (breast meat and liver),

- o Two northern harrier (eggs), and
- o Two mourning doves (juvenile).

5.2 ARSENIC IN PLANTS

Pathways analysis of arsenic in biota shows that plant species vary widely in their sensitiveity to arsenic. Although arsenic is not biomagnified in food chains, plants which tolerate high arsenic concentrations may contain enough arsenic to become toxic to animals which consume them (Porter and Peterson, 1975).

Results of the RMA Phase I soils studies indicate that several source areas have elevated arsenic concentrations in the surface soils. These concentrations may be enough to produce toxic effects in plants, or if the plant species present are arsenic resistent, may build up concentration in the plant tissues which could be toxic to animals that would consume the plants.

Two plant species (Helianthus annus and Convolvulus arvensis) will be collected from Basin A, Basin C, and from an onpost control area in section 19 and analyzed for contaminants as indicated in Table 5.0-1. These data will be used to evaluate arsenic toxicity in these basins.

6.0 CRITERIA DEVELOPMENT

Key chemicals of concern to biota will be identified using all available information on the distribution and concentration of RMA contaminants in the abiotic environment and on the hazard potential of these chemical contaminants to biota. Criteria used to evaluate these chemicals includes: octanol-water and carbon-water partition coefficients, water solubility, depuration rate, metabolism/biodegradation information, bioconcentration potential, biomagnification potential, and toxicity information. Both lethal and sublethal effects, and contaminant levels in biota and their environment will be evaluated.

Biota will be assessed from three aspects of consideration:

- o Protected and regulated species (e.g., bald eagle),

- o Species which are important components in the structure and function of regional ecosystems (e.g., prairire dogs); and
- o Species which might serve as pathways of contaminant transfer to humans (e.g., deer, waterfowl, cottontails, pheasant).

This information will be assessed in conjunction with the onpost and offpost endangerment assessments (Tasks 35 and 39) and the U.S. Army Medical Bioengineering Research and Development Laboratory.

Pathways analyses will be used to evaluate the potential for harm from major contaminants of concern (e.g., aldrin, dieldrin, endrin, mercury, arsenic) to selected species, regional ecosystems, and humans as described above. Additional contaminants of concern will also be evaluated, based on existing information and on data developed as the result of soil and water tasks.

Pathways information will be developed in conjunction with food habits investigations and food web studies. The approach used will be to analyze food subwebs (sink food webs) which are representative of the major ecosytems on RMA. Rather than address all species in the major animal communities, a sink food web approach is used. A sink food web represents all prey of a particular consumer, all food of those prey, and so on. To develop criteria, appropriate models are then used which incorporate information on feeding rates, assimilation efficiencies, depuration rates, bioconcentration factors, proportion of prey consumed, etc., to produce an estimate of the interrelationship between concentrations of contaminants in physical media (e.g., soil) and those found at selected levels in the food web. This information is then coupled with data on the relationship between tissue concentrations and adverse effects to produce an estimate of the concentration permissible in soil that will not produce adverse effects in the species under consideration.

Two sink food web models were developed which represent the terrestrial and aquatic ecosystems. The "sink" species representative of each were selected for the following common reasons:

- o Their known sensitivity to major contaminants at RMA, and

- Their position at the top of their respective food webs, thus representing the maximum potential for bioaccumulation, and because they included important game species which are potentially important in the human pathway.

The American kestrel was selected to represent the terrestrial ecosystems because of existing information on RMA that indicated adverse reproductive effects related to RMA contamination. The bald eagle was originally selected to represent the aquatic ecosystem because this species was known to visit RMA, because it is an endangered species, and because existing literature indicated that it feeds predominantly on fish. Subsequent observations of the bald eagles wintering on RMA indicated that their food was primarily terrestrial, thus food webs for aquatic and terrestrial sources are evaluated.

Sink food web models are based on information from published sources, supplemented with observations and data collected at and near RMA. Single species are used in some instances to represent entire taxonomic and trophic groups (e.g., grasshoppers are used to represent all insects) in order to simplify the models, and because of their abundance in the RMA environment and in the diet of species of concern. Subweb models for the American kestrel and bald eagle are presented in Figures 6.0-1 and 6.0-2, respectively.

7.0 AQUATIC STUDIES

Information on the aquatic ecosystems at RMA and in offpost control areas is being collected by MKE. Data collected will include water quality measurements, fish population characteristics, and chemical analyses of selected plant and animal species. It is anticipated that this information will be provided in report form for incorporation into the Biota section of Remedial Investigation documents.

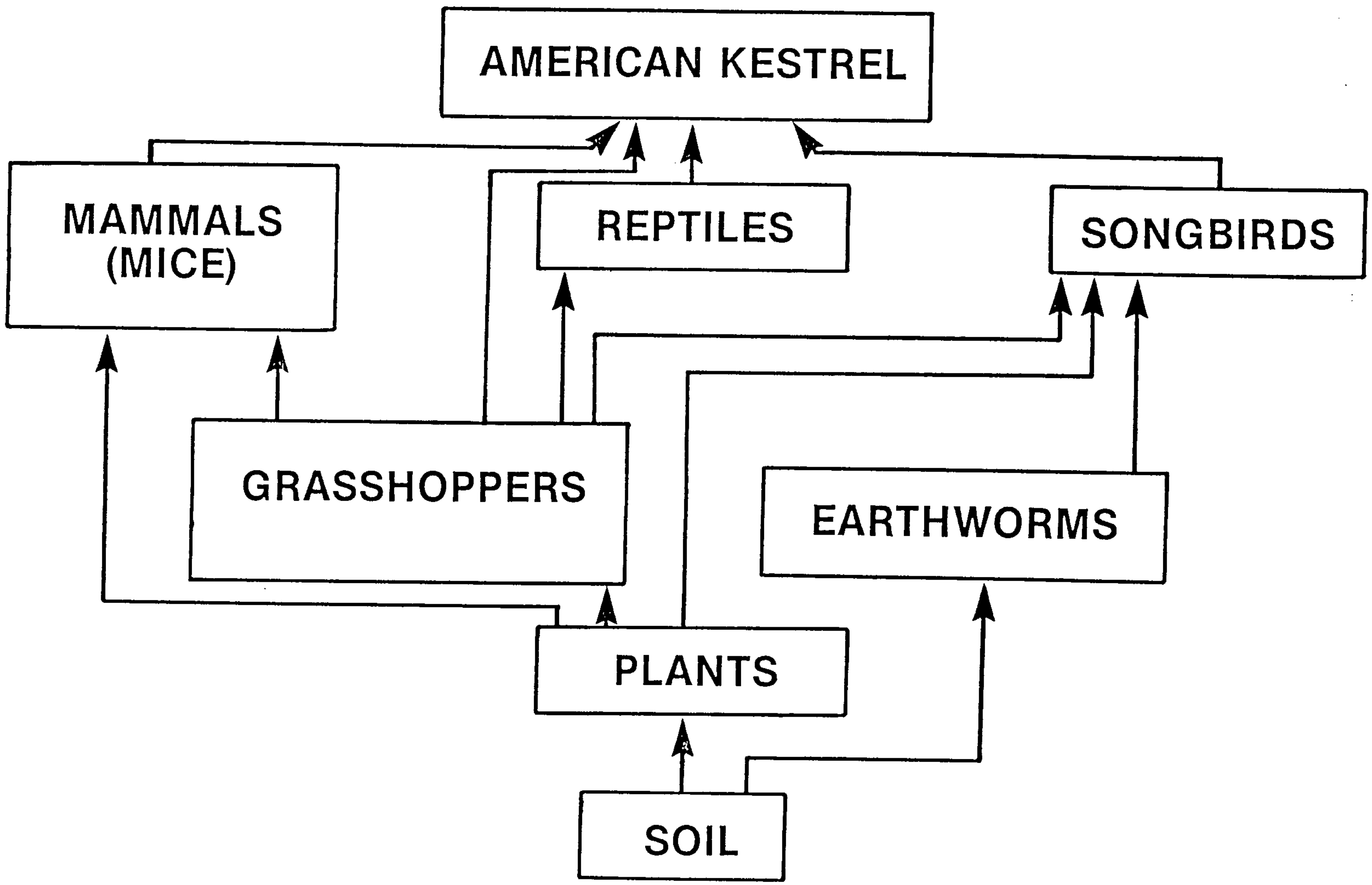


Figure 6.0-1
KESTREL "SINK" FOOD WEB

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

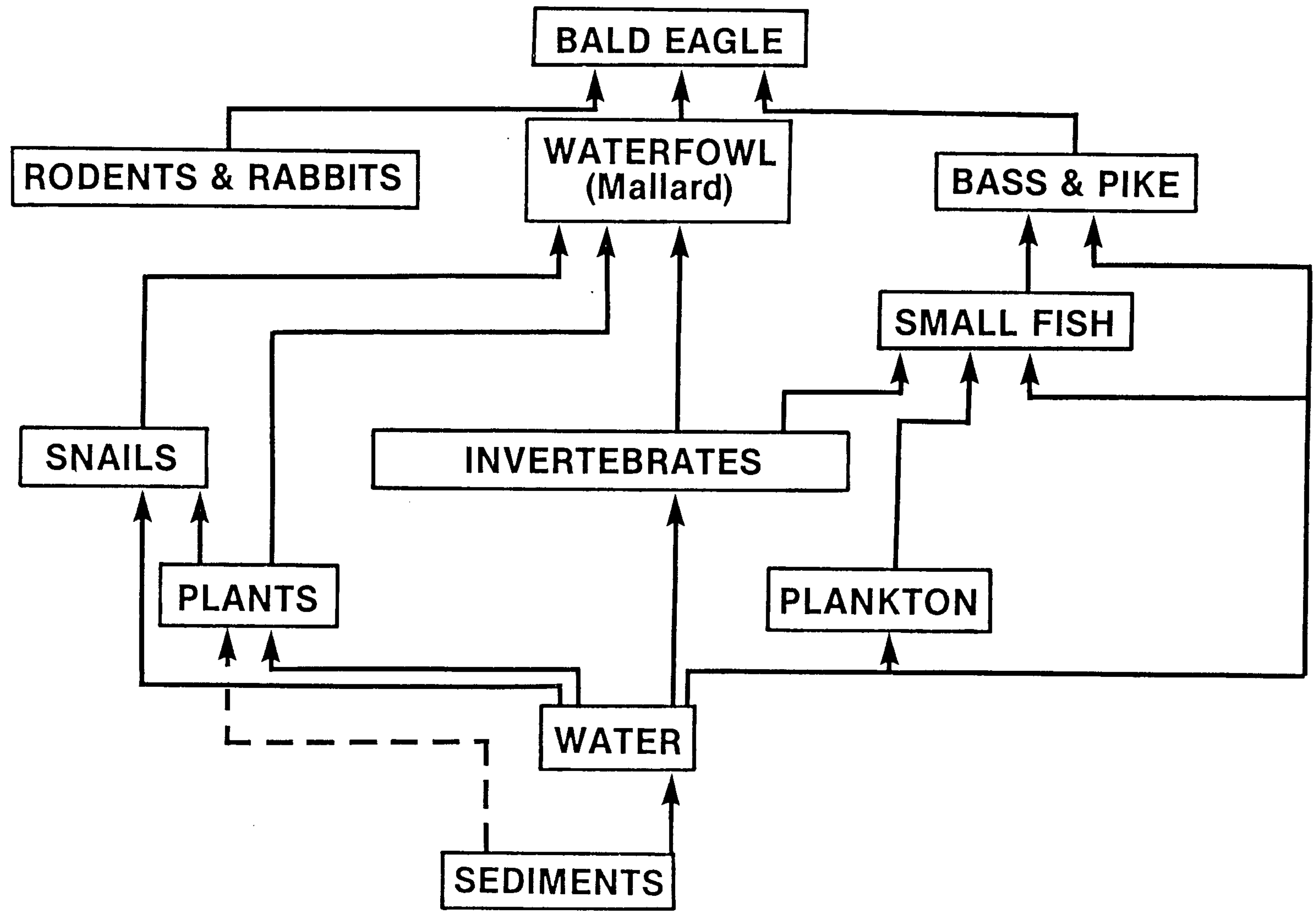


Figure 6.0-2
BALD EAGLE "SINK" FOOD WEB

Prepared for:
U.S. Army Program Manager's Office
For Rocky Mountain Arsenal
Aberdeen Proving Ground, Maryland

8.0 REFERENCES

Call, M.W. 1978. Nesting Habitats and Surveying Techniques for Common Western Raptors. Bureau of Land Management, Denver Service Center, Colorado.

Errington, P.L. 1930. The Pellet Analysis Method of Raptor Food Habits Study. Condor 32:292-296.

RIC#86251R01
Environmental Science and Engineering, Inc. (ESE). 1986. Rocky Mountain Arsenal Phase II Draft Final Technical Plan. Task 9 (Biota Assessment). Prepared for Office of the Program Manager, Rocky Mountain Arsenal.

Fuller, M.R. and J.A. Mosher. 1981. Methods of Detecting and Counting Raptors; a review. Stud. Avian Biol. 6:235-246.

Kochert, M.N. 1986. Raptors. Pages 313-349 in Cooperrider, A.Y.,R.J. Boyd and H.R. Stuart.eds. U.S. Dept. Interior: Bureau of Land Management. Service Center. Denver, Co. 858 pp.

Mersman, T.J., D.A. Buehler, and J.D. Fraser. 1987. Bald Eagle Food Habits; An Examination Techniques. Paper presented at the Raptor Research Foundation Annual Meeting. Boise, Idaho.

Moore, T.D., L.E. Spence, C.E. Dugnolle and W.G. Hepworth. 1974. Identification of the Dorsal Guard Hairs of Some Mammals of Wyoming. Wyoming Game and Fish Department. Bull. No. 14. 177pp.

Platt, J.B. 1976. Bald Eagles Wintering in a Utah Desert. Am. Birds 30(4):783-788.

Polonsky, A.P. Unpublished. Food Habits and Lead Occurrence in Bald Eagles Wintering in Colorado. 15 pp.

Porter, E.K. and P. J. Peterson. 1975. Arsenic Accumulation by Plants on Mine Waste (United Kingdom). In: E.A. Woolson 1983, Emissions, Cycling, and Effects of Arsenic in Soil Ecosystems. In: Biological and Environmental Effects of Arsenic. B.A. Fowler, Ed. Elsvier Science Publishers. NY. pp. 51-120.

Stalmaster, M.V., and J.R. Newman. 1978. Behavioral Responses of Wintering Bald Eagles to Human Activity. J. Wildl. Manage. 42:506-513.

Steenhof, K. 1978. Management of Wintering Bald Eagles. Fish and Wildlife Service, U.S. Department of the Interior, Columbia, Missouri. 59 pp.

Southern, W.E. 1967.Further Comments on Subadult Bald Eagle Plumage. Jack Pine Warbler. 45(3):70-80.

The Task 9 Letter Technical Plan was distributed on April 14, 1988 to all Organizations and the State (OAS). Comments were received from Shell Oil Company on May 13, 1988. Comments were received from U.S. Fish and Wildlife Service and revised comments were revised on July 15, 1988. No comments were received from the U.S. Environmental Protection Agency or from the State of Colorado.

WW 5/17

Shell Oil Company

c/o Holme Roberts & Owen
Suite 1800
1700 Broadway
Denver, CO 80290

May 13, 1988

FEDERAL EXPRESS

Mr. Donald L. Campbell
Department of the Army
Office of the Program Manager
Rocky Mountain Arsenal
Contamination Cleanup
ATTN: AMXRM-EE
Bldg. 4460
Aberdeen Proving Ground, MD 21010-5401

Re: United States v. Shell Oil

Dear Mr. Campbell:

Enclosed please find Shell Oil Company's comments on the Army's Draft Technical Plan for the Biota Phase II Assessment, dated April 14, 1988.

Sincerely,

Robert D. Lundahl

Robert D. Lundahl
Manager, Technical

RDL/mp/14780

Enc.

880991-1/2

RESPONSES TO SHELL OIL COMPANY COMMENTS ON THE BIOTA ASSESSMENT LETTER TECHNICAL PLAN APRIL 1988

GENERAL COMMENT: It is difficult to tell from the wording of the Plan whether some of the work is completed, or all of it remains to be done. More judicious use of past, present, and future tenses would facilitate such an understanding.

Response: Comment noted.

SPECIFIC COMMENTS

Comment 1: Letter of Transmittal

The fourth paragraph states that prairie dogs are "a habitat provider for diverse wildlife..." We agree that prairie dogs are a major prey species for a variety of predators, and we assume that it is this role, particularly regarding bald eagles, that has precipitated continued prairie dog studies. We recognize the purpose of conducting black-footed ferret surveys, but it is extremely unlikely that ferrets occur at RMA. We therefore urge the Army not to allow this remote potentiality to be blown out of proportion.

We believe that extensive prairie dog towns such as are found on RMA destroy habitat for many more species than they provide habitat for.

Response:

Prairie dogs occupy approximately 5,000 acres of RMA. They provide habitat and prey resources for a variety of species including burrowing owls, ferruginous hawks, Swaison's hawks, golden eagles, and bald eagles. Prairie dogs are also subject to potential contamination, thus posing possible hazard to other wildlife species that feed on RMA. These reasons, in addition to their use by bald eagles, justify their continued investigation.

A black-footed ferret survey was requested by the U.S. Fish and Wildlife Service (USFWS) prior to implementation of the Army's prairie dog poisoning program and other planned disturbances on RMA. The survey was triggered by criteria and conducted in a manner totally consistent with the guidelines provided by the USFWS for such surveys.

It is generally acknowledged that prairie dog towns increase the diversity of prairie habitat when compared to surrounding prairie without prairie dogs (Clark et al., 1982. Prairie dog colonies and associated vertebrate species. Great Basin Naturalist 42: 572-582;

Coppock *et al.*, 1983a. Responses of Bison to modification of vegetation by prairie dogs. Oecologia 56: 10-15; Coppock *et al.*, 1983b. Effects of black-tailed prairie dogs on intraseasonal aboveground biomass, nutrient dynamics, and plant species diversity. Oecologia 56: 1-9.; Agnew *et al.*, 1986. Flora and fauna associated with prairie dog colonies and adjacent ungrazed mixed grass prairie in western South Dakota. J. Range Management 39: 135-139).

A number of bird species depend on black-tailed prairie dog habitat as feeding, resting, and nesting habitat (see Knowles *et al.*, 1982, Condor 84: 71-74 , among others). Burrowing owls depend on prairie dog burrows for nesting sites throughout most of their range (Butts and Lewis 1982. The importance of prairie dog towns to burrowing owls, Proc. Okla. Acad. Sci. 62: 46-52, among other refs.). We have found no published account of any location where black-tailed prairie dog colonies have led to the elimination of habitat for any native plains species.

<u>Comment 2</u>:
p. 1, paragraph 1

Merely discussing the bald eagle study plan does not signify an agreement between the parties.

<u>Response</u>:

A consensus on the general scope and objectives of these studies was provided at the bald eagle meeting held on January 8, 1988. Shell, HRO, and MKE were present at this meeting.

<u>Comment 3</u>:
p. 1, paragraph 3

Please clarify whether the work by ESE in support of the offsite eagle studies is considered a part of this technical plan.

<u>Response</u>:

The U.S. Fish and Wildlife Service (USFWS) study is a regional study encompassing RMA and the surrounding area. ESE involvement in these investigations relates to the eagles using RMA and is part of this technical plan.

<u>Comment 4</u>:
p. 2, paragraph 4

Periodically alternating transect direction is itself a bias. Route direction should be selected on the basis of specific criteria that are applied consistently. Leaving discretion to the observer in order to maximize results will render meaningless any comparison of data. Moreover, the items listed in the first line (weather, season, time of day) are not really biases; they simply are variables that should be addressed in designing the sampling program.

<u>Response</u>:

Alternating transects reduced the bias of always repeating the same route and introducing the systematic bias of consistently not counting in some areas of known raptor habitat (e.g., areas not visible from any single

set of routes). Alternation of transects to reduce bias is a recommended method used for raptor transect surveys (Kochert, M.N. 1986. Raptors In Cooperreider, A.Y., R.J. Boyd, and H.R. Stuart. eds. Inventory and Monitoring of Wildlife Habitat, U.S. Department of Interior, Bureau of Land Management, Denver, Colorado). "Leaving discretion to the observer in order to maximize results" as stated in Shell's comment was not indicated in the technical plan and never occurred.

Comment 5:
p. 2, paragraph 4

How will "evening or morning" be selected? Why not be consistent?

Response:

On many occasions both counts were conducted, although some were missed because of scheduling and weather problems. Consistency is desirable, but not necessary in order to obtain useful information.

Comment 6:
p. 2, paragraph 3

Why were counts conducted at different intervals in the different years?

Response:

We were unable to find the subject of this comment in the location referenced. We assume this comment refers to page 3, paragraph 3. If so, the change to a shorter time interval during the second year was used in similar studies (Raptor Research Foundation Annual Meeting, Boise, Idaho, October, 1987). We believe that this change was justified in order to make our data more compatible with that collected by other researchers.

Comment 7:
p. 4, last word

As we commented on a previous draft, the word "shot" should be added after "lead." Otherwise, it appears that the castings are somehow being analyzed for elemental or ionic lead.

Response:

See text for change.

Comment 8:
p. 5, last paragraph

We do not understand how the sampling program relates to seasonal shift in diet. If the question is simply, "What contaminant levels occur in prey species from different parts of RMA?," then it would seem that the earlier ESE and MKE tissue sampling programs would suffice. As we read it, this effort is redundant with previous efforts.

A second concern is whether eagles have been documented to consume prey from Section 36. If not, then we question whether these data are relevant.

Response:

RMA contaminants that could accumulate in prey species during the summer could be slowly lost over a period of weeks or months through depuration as fall and winter progress. A shift in the diet of prey species (e.g., from green plants of some species to dried portions of

others) might also allow for intake of additional contaminants or increase contaminant concentrations as a result of consuming different food.

The earlier ESE program did not collect samples of prey species for tissue analysis during the winter when raptors, including bald eagles, were feeding heavily on these prey, and did not include prey samples from the toxic storage yard. Collection of additional samples was requested by the U.S. Fish and Wildlife Service and agreed to by the Army as a logical extension of the biota assessment program. MKE's tissue sampling program as described in their technical study plans was likewise insufficient with respect to prey contamination concerns. This effort was clearly not redundant with previous efforts for the aforementioned reasons.

Bald eagles have been observed consuming prey from section 36 (see Bald Eagle Study Draft Final Report provided to Shell in December 1987). We believe that the study would still be of value because eagles might consume prey from contaminated areas (section 36 and others on RMA) in the future prior to remediation.

Comment 9:
p. 6, paragraph 2

Please clarify whether the raptor nest surveys described in Section 1.7 are part of the comprehensive monitoring program. MKE collected nesting data on RMA in 1986 and 1987. We believe that additional surveys are unnecessarily duplicative unless a better justification is provided.

Response:

Raptor surveys described herein are not part of the comprehensive monitoring program. The surveys were requested by USFWS, agreed to by the Army, and conducted by ESE in order to provide the necessary data to the USFWS in a timely manner. The small level of effort involved in this work was justified in order to comply with the urgent need for information and because MKE's Wildlife Study Plan had indicated only one such nesting survey, completed in 1986.

The need for additional information is justified as raptors may feed in areas of potential contamination some distance from where they nest, all sites of RMA contamination had not been defined at the time of this investigation, and because areas of RMA other than those directly designated as contaminated are likely to be affected by remediation activities (e.g., incinerator construction, landfills, roads, utilities, etc.) yet to be determined.

Comment 10:
p. 7, paragraph 2

Shell does not recall that the prairie dog studies were previously described or agreed upon. Again, what is past tense, and what is future?

<u>Response</u>: Prairie dog studies were discussed at Biota MOA Subcommittee meetings in 1987 (see minutes of the 22 September 1987 meeting and earlier). ESE conducted the winter study in conjunction with USFWS needs for winter prey base information.

<u>Comment 11</u>:
p. 8, paragraph 1

We understand the need for the first criterion at the top of the page, but not the second or third. If the sites are randomly located, how can they be duplicated? Of greater concern, why are (were) prairie dog density surveys not conducted in "contaminated" areas? This is inconsistent with the collection of prairie dog tissues from Section 36 and the Toxic Storage Yard (page 6).

<u>Response</u>: Random plot selection by the grid method can lead to duplication in as much as the same combination of coordinates can be selected more than once. The objective of the first prairie dog study was to estimate the prairie dog densities in uncontaminated areas as a basis for estimating possible baseline conditions.

<u>Comment 12</u>:
p. 8, paragraph 2

Why use different methods for winter versus summer, especially regarding location in Section 36?

<u>Response</u>: The objectives of the winter study differed from the objectives of the summer study. The winter plan was adjusted to provide data on densities in the three major prairie dog towns on RMA, one of which included sites of known contamination, as a basis for evaluating prey for winter raptors. Inasmuch as raptors were known to feed in areas of contamination (e.g., section 36), the winter study included these sites.

<u>Comment 13</u>:
p. 10, paragraphs 1 and 2

We question the validity of a ferret survey so far in advance of any expected disturbances. Will they have to be repeated when remediation is designed?

<u>Response</u>: The ferret surveys were conducted prior to planned prairie dog poisoning and land disturbances associated with Basin F Interim action.

Both disturbances fell within the time frame covered by this survey. The study also provided a basis for evaluating RMA in relation to this endangered species. It is anticipated that black-footed ferret surveys will be conducted in the future as needed for implementation of the maintenance program, interim actions, and site remediation.

<u>Comment 14</u>:
p. 10, paragraph 3

We would like to see an explanation of why the additional data on invertebrate populations are being sought.

Response: The additional invertebrate population studies were needed because of the small sample sizes and inconclusive data acquired during the earlier studies.

Comment 15:
p. 10, paragraph 4
Are these the "samples of chance?" How is fulfillment of the second bullet made? Why exclude lower trophic levels? This would bias the results.

Response: The animals described in paragraph 4 on page 10 are defined as samples of chance in paragraph 1 on page 13.

Fulfillment of the second bullet is made by observing the condition and/or behavior of the organism. Signs such as convulsions, lethargy, emaciation, etc. are used in making the judgement.

Lower trophic levels are not represented in the samples of chance because they are adequately covered in the tissue sampling program. Representatives of higher trophic levels were not included in the overall sampling design because collecting samples could adversely affect populations of these species (which are normally much lower than the populations of species at lower trophic levels), and because many of these species are protected (e.g., hawks, owls, eagles). We do not agree with the comment that exclusion of lower trophic levels from this aspect of the program biases the results.

Comment 16:
p. 12, Table 5.0-1
Why no data for As or DDE/DDT for aquatic macrophytes. We suggest changing "morning glory" to "field bindweed" to avoid confusing Convolvulus with Ipomaea.

Response: Arsenic has not been identified as a contaminant in the aquatic ecosystems sampled under this program.

DDE and DDT were not identified as major contaminants of concern in the lakes. The potential effect of these contaminants would be greatest in animals, many of which are being analyzed for these chemicals.

Standardization of common plant names is not necessary when the scientific name is provided. We see no need to make this change.

Comment 17:
p. 13, paragraph 3
The two plant species were not, to our knowledge, previously discussed as being selected for tissue analysis.

Response: These species were mentioned as potential species for analysis during the July 1987 Biota MOA subcommittee meeting, but were not specifically mentioned in the minutes of that meeting.

Comment 18:
p. 13, paragraph 2

It is not clear whether the "20 to 30 samples" are the samples of chance, or where that number came from.

Response:

The 20 to 30 samples are among the samples of chance. The numbers are estimates.

Comment 19:
p. 13, paragraph 3

We doubt that the USFWS specimens will meet USATHAMA requirements because of their long period of storage. Do Chain-of-Custody forms exist for these samples?

Response:

The USFWS specimens meet the USATHAMA holding time and temperature requirements as discussed at the 10 February 1988 Biota MOA subcommittee meeting and subsequently implemented by USATHAMA. Chain-of-custody forms exist for these samples, although they do not meet the litigation quality requirements of the other samples collected under the Biota Assessment program.

Comment 20:
p. 14, paragraphs 3 and 4

What are the As levels found which the Army believes are high enough to have phytotoxic effects? How will the data on As levels in sunflower and bindweed be used to evaluate As toxicity in the basins?

Response:

Responses to these questions are inappropriate at this time inasmuch as they address questions of interpretation and not methodology.

Comment 21:
p. 15, paragraph 2

We would appreciate more detail on the role of USAMBRDL, and what is meant by "assessed." Is this qualitative or quantitative?

Response:

USAMBRDL provides technical support to both the Biota Assessment Task and the endangerment assessment tasks. See the technical plans for Tasks 35 and 39 for additional information.

Comment 22:
p. 14, paragraph 4

We recommend against using the term "sink food web," because this seems to imply a closed system from which nutrients, contaminants, or energy cannot exist. The webs depicted by Figures 6.0-1 and 6.0-2 are simply "food webs" for the two raptors chosen.

More important, we question the validity of the entire process as described in this paragraph. Are the "proportion of diet" data based on the literature or site specific studies? For how many plant, reptile, or songbird species will contaminant data be available? Some songbirds are granivores, other insectivores. Some are migratory, others resident. It would seen that even relatively small changes in diet could have substantial impact upon what concentrations in the soil are deemed acceptable.

A less detailed approach (soil-plants-herbivors-carnivores) using general bioconcentration factors would give more generalized results. This would allow for "order of magnitude" evaluations that do not convey an erroneous notion of accuracy or precision. Perhaps this would be sufficient.

Finally, we wonder how the "adverse effects" will be defined, and levels that cause them determined. If this is to be based on the literature, it should be so stated.

We understand that a food web analysis is necessary, but we are concerned about such a complicated approach, which still falls short of the actual complexity of predator-prey-soil interactions. Every step in the complex process will probably end up being a "conservative, worst-case" assumption which, compounded throughout the webs, could result in untenably low "permissible soil concentrations."

Response: The term "sink food web" is well established in the scientific literature and is more precise than the more general term food web. See Cohen, J.E. 1978. Food Webs and Niche Space, Princeton Univ. Press, Princeton and Pimm, S.L. 1982. Food Webs. Chapman and Hall, London for definitions of different food webs.

Many of the issues expressed regarding the pathways analysis process require detailed information currently being developed as part of the "How Clean Is Clean?" efforts. Concerns expressed regarding this approach will be addressed at the time the pathways analyses have been reviewed and made available for comment as part of the Biota RI and Endangerment Assessment documents.

Shell's pessimistic evaluation of the pathways analysis process is unfounded.

Comment 23: The work on American kestrel reproduction should be explained here, or at least referenced. The existing literature for bald eagles includes references to a shift from fish to other food-such as rabbits and carrion--when lakes and rivers are covered with ice. We do not necessarily disagree with the choice of these two species. However, coyotes also are high level predators which are resident on RMA and relatively long-lived.

Response: Birds in general are more susceptible to the effects of certain contaminants than are mammals. Previous studies conducted on RMA by the USFWS used kestrels because they are abundant, have relatively small home ranges, and are sensitive to some RMA contaminants (e.g., organochlorine pesticides). Similar justification does not apply to coyotes.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
FISH AND WILDLIFE ENHANCEMENT
COLORADO STATE OFFICE
529 25½ Road, Suite B-113
GRAND JUNCTION, COLORADO 81505
(303) 243-2778

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

(FWE)

July 12, 1988

Colonel Wallace N. Quintrell
Program Manager, Rocky Mountain Arsenal
Department of the Army, USATHMA
Building 4435
Aberdeen Proving Ground, Maryland 21010-5401

Dear Colonel Quintrell:

This is a revised response to our review of a RMA Biota Assessment Letter Technical Plan dated April 1988, Contract No. DAAK11-84-D-0016, Task No. 9, prepared by ESE. These comments supersede our letter dated May 16, 1988. Recent discussions with your staff reveal that our original letter included a statement in the fourth paragraph regarding Service responsibilities that could be misconstrued. The second and third sentences of that paragraph have been revised to more accurately portray our position.

Although the work outlined in this Plan has already been done (i.e. this is an after the fact review) we have provided you with a few comments.

On page 4, last sentence, it is not clear what is meant by checking eagle castings for evidence of lead. Is this physical (e.g. x-ray) or chemical evidence? Also, how does the observer or collector differentiate between castings from golden vs. bald eagles; can they be identified separately?

We have questions regarding the "sink" food web models on pages 15 and 16. Will levels of contaminants in soils and sediments considered safe for modeled species also afford protection for a host of other migratory birds that either breed on or intermittently spend time on the RMA? For example, does the contaminant pathway and predictive exposure to American kestrels also account for pathways and exposure to Swainson's hawks, burrowing owls or great-horned owls? Or, do pathways and modeling including mallards and bald eagles account for exposure to diving ducks or fish-eating waterbirds?

The preceding questions are fundamental to the reason the Fish and Wildlife Service has recently began gathering literature information on pathways and exposure to species not included in the ESE "sink" models. Because the Service has concern for all migratory birds, the Service will consider all of the species common to the RMA from the standpoint of pathways and exposure. Although we recognize the impracticality of modeling for all species, the Service will be developing its own evaluation of target concentrations in soils

or sediments. This evaluation must be more comprehensive than is provided for by the list of species now included in current ESE models. Also, the Service effort to gather literature will be useful in evaluating the assumptions and conclusions of the ESE modeling effort once it becomes available for Service review.

Thank you for the opportunity to comment on the subject document, and for the opportunity to clarify comments made in our original response. Please contact Mr. Rod DeWeese at FTS 776-2675 in Golden, Colorado if you have questions about these comments.

Sincerely,

Jeffrey D. Opdycke
State Supervisor

cc: Bob McCue, FWS
Tom Jackson, FWS
Bob Stewart, DOI
Connally Mears, EPA
Douglas Reagan, ESE

**RESPONSES TO U.S. FISH AND WILDLIFE SERVICE
GENERAL COMMENTS ON THE LETTER TECHNICAL PLAN
July 1988**

GENERAL COMMENTS IN COVER LETTER

Comment 1: On page 4, last sentence, it is not clear what is meant by checking eagle castings for evidence of lead. Is this physical (e.g., x-ray) or chemical evidence? Also, how does the observer or collector differentiate between castings from golden vs. bald eagles; can they be identified separately?

Response: Castings were dissected to detect the presence of lead shot. Castings of bald eagles could not be differentiated from golden eagles castings on the basis of physical examination, therefore castings were collected only from beneath known bald eagle perches and from the roost area. Areas of mixed eagle use and golden eagle use were avoided.

Comment 2: We have questions regarding the "sink" food web models on pages 15 and 16. Will levels of contaminants in soils and sediments considered safe for modeled species also afford protection for a host of other migratory birds that either breed on or intermittently spend time on the RMA? For example, does the contaminant pathway and predictive exposure to American kestrels also account for pathways and exposure to Swainson's hawks, burrowing owls or great-horned owls? Or, do pathways and modeling include mallards and bald eagles account for exposure to diving ducks or fish-eating waterbirds?

Response: The Army recognizes and welcomes the prominent role that the Service has with respect to both Biota Products and the Endangerment Assessment through the provision of relevant information on levels of contaminants in Arsenal soils and surface water that the Service believes will be protective of wildlife, as well as the Service's participation in the pertinent deliberations. The setting of target levels for Arsenal contaminants will be set by the Army, as the lead agency, in accordance with the terms of the RI/FS Process Document which provides for deference to be accorded to the Service's views.